The Dock and Harbour Authority

No. 285. Vol. XXV. Edited by BRYSSON CUNNINGHAM, D.Sc. B.E., F.R.S.E., M.Inst.C.E. July, 1944

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Editorial Comments

Harbour Model Stations.

The field of review of this Journal, in regard to the present state of port and harbour developments being strictly curtailed by the war-time censorship, we have largely to fall back on material, which, though strictly appertaining to the pre-war period, is still serviceable in the way of imparting information and knowledge. This month we reproduce an extremely useful Paper on the Experimental Station at Vicksburg, Miss., U.S.A., for harbour and river problems in the United States. The station has done much valuable research work during more than a dozen recent years and, so far as we are aware, continues to discharge its useful functions. We have no doubt that it has proved of considerable utility in regard to war-time problems, though detailed reference thereto may not be made.

We think our readers will derive from Brigadier-General Tyler's Paper much serviceable information about the construction and application of harbour models, the necessity for which is, appropriately enough, attested by the reference in a subsequent Comment to the Range Problem now engaging attention at Cape Town Harbour.

The Invasion.

It would ill become a Journal such as this, professing to provide a record of current events, even though limited in scope to a particular field, to ignore altogether one of the most momentous crises in European—nay, in mundane—affairs, and to pass over the tremendous event which has happened during the past month without making some allusion to it and commenting on its possible repercussions in the domain of port operation. After months and years of patient and diligent preparation, the Allied Nations, gathering up their accumulated strength, have struck with their combined forces a mighty blow in the cause of human liberty and for the restoration of freedom to the enslaved states of Europe. Full information respecting the military and strategic movements will have been obtained by our readers from day to day press reports, and it only devolves upon us to make observations on such aspects of the matter as fall legitimately within the sphere of maritime interests.

It is generally recognised that the invasion of Europe from the West—popularly termed the Second Front—was a sea transport operation of the first magnitude. Scores of thousands of men and vast quantities of materials and equipment have been successfully transported across the English Channel in circumstances which are unique in the history of navigation. Some four thousand vessels of substantial calibre, accompanied by innumerable craft of smaller size, took part in an operation which tested to the full the capabilities of accommodation and facilities at certain ports on the Southern coast of this country. Very briefly, it involved a programme in which figured in sequence, English ports, Allied shipping and French beaches.

A primary reflection is that there was a vast difference between the conditions of embarkation and those of ship discharging. On the English side of the Channel, loading was done by carefully-planned, well-organised routine at properly equipped quays, with excellent facilities for the handling of cargo, including heavy-lift cranes for ponderous tanks and unwieldy bulldozers. Stevedoring operations were carried out by trained gangs in perfect order and regularity, without undue haste or liability to confusion.

On the French coast, the picture was entirely different. The enormous mass of heterogeneous, irregular freight had to be turned out with the utmost possible speed and despatch on to open beaches, exposed to weather conditions which were none too favourable, to say at least, under persistent gunfire and threat of air attack, amid traps, barbed wire entanglements and obstacles of all kinds prepared by an ingenious and resourceful adversary during months of elaborate toil. There could not have been a greater contrast.

Yet despite adverse circumstances the work was performed with surprising method and regularity. Mr. C. W. Kingdom, representing the combined Press, wrote as follows: "Surrounded by other coasters of about the same size and tonnage, a company of the Royal Engineers is unloading our general cargo of stores and spares into a myriad of Army "Ducks." The "Ducks" come alongside, take a couple of slings and are away in ten minutes. Laboriously, they crawl ashore with their freight, up over the sands to disappear into a small French village, where for the last three days the Tricolour flag has again been flying over the Town Hall. The clatter of the winches and shouts of Army stevedores are punctuated by loud explosions as mine-detecting squads set off hidden traps left on shore by the Jerries. When I come to weigh up my impressions of the initial stages the thing which stands out is the marvellous organisation. . . ."

Without question, the stevedoring arrangements must have called for the highest degree of skill and competence. Cargo had to be shipped in conformity with the vessel's trim, taking into account

Editorial Comments—*continued*

special discharging requirements. The heavy cargo could not all be stowed at the bottom of the hold as is the normal practice, but priority cargo was placed in the holds irrespective of position and weight.

There was an interesting point in connection with the tides. For obvious reasons, spring tides were desirable, but the enemy miscalculated in imagining that advantage would be taken of their exceptional height. On the contrary, landings were made at low water on flat expanses of beach which enabled the shore defences of the "Atlantic Wall" to be penetrated and demolished without serious difficulty.

Altogether, it was a remarkable operation, comprehensively prepared and brilliantly executed. The greatest possible credit for this opening phase of the Invasion attaches to all railway and port officials in this country who tabulated and synchronised the movements of troops and materials in accordance with the military schedule. While paying homage to the bravery of the fighting men it is only right to add a respectful tribute to those who in various ways actuated the machinery and smoothed the path of the invaders.

A South African Harbour Problem.

The Railways and Harbours Administration of the Union of South Africa is experiencing some disappointment and difficulty in connection with the functioning of the new Duncan Dock at Cape Town, recently completed to make provision for increased demands for shipping space, the former Basin having proved inadequate for growing requirements. Trouble has arisen which is due to a cause already explained in this Journal in a Paper by Mr. George Stewart, M.Inst.C.E., on "Range Action in Harbours," presented rather more than a year ago to the Institution of Civil Engineers, and published in the Institution Journal. It appeared in our issue of April, 1943.

There are certain weather conditions at Table Bay in which a swell, or range, locally known as "run," is produced in the offing and this enters the harbour causing considerable disturbance in the interior and affecting the vessels moored alongside the quays. In a recent case it is reported that after prolonged buffeting against the timber fender work, a ship broke loose from its moorings and sustained severe damage, in compensation for which £13,000 had to be paid.

Mr. Stewart, in his Paper, explains that according to his researches, range or "run" occurs in the enclosed basins or Table Bay Harbour under two weather conditions, viz. (1) a swell in and near Table Bay, due to a distant wind or storm, and (2) a wind from the north-west during winter gales. It is generally held among experienced engineers and mariners familiar with the harbour, that the phenomenon is due to reflection of wave energy from an adjacent beach. Mr. Stewart's observations showed that a maximum height of range of 3-ft. 6-in. was attained in the Victoria Basin and 3-ft. in the new basin (Duncan Dock).

He proceeded to investigate the problem by means of a model of the harbour to scales of 100 feet to the inch horizontally, and 10 feet to the inch vertically, arranged in a tank, 14-ft. by 8-ft., at Cape Town University, waves being generated by suitable mechanism. The conclusions he came to (amongst others) were that sea alone does not cause range; that waves of short period have no effect in either basin; that the principal cause of range is wave reflection from the beach towards the breakwater; that spurs, or groynes or wave traps, built out on either, or both, sides of the harbour basin entrances, do not appreciably decrease the range action and that, finally, the most effective preventive would be a breakwater extending across the Bay from the Milverton Beach to the end of the existing breakwater, a distance of 13,000 feet.

The matter has been considered of sufficient seriousness to justify investigation by a Select Committee, before whom Mr. C. M. Hoffe, General Manager of the Administration, recently gave evidence. He announced that the Administration has now under observation a larger scale model than that devised by Mr. Stewart, and that a special research engineer had been put in charge of the experimental tests.

Without a prolonged and thorough knowledge of all the local conditions, it is not possible to offer any serviceable contribution towards the solution of a problem of so baffling a nature, but it seems evident on the facts as stated, that the authorities will be bound to take steps by the formation of an outer breakwater, as proposed by Mr. Stewart, or otherwise, to ensure the greater security of craft within the harbour waters. The matter is of undoubted concern to the Administration, which is, of course, legally responsible for the safety of shipping using the harbour. Moreover, there is linked up with the range question, the serious erosion of the Woodstock Beach, just outside the harbour limits, much damage having been done to the beach and to the coast road. It is to be hoped that a satisfactory solution of the problem may soon be found, though it may be that remedial measures will prove costly. A breakwater of the length suggested, partly in deep water, would be a serious addition to the outlay on the harbour works, which, with the new large graving dock now in hand, has already attained a striking figure.

Notable Coal Dumper at Durban.

In the Notes of the Month for the June issue was included a reference to certain improvements at the Port of Durban, Natal, about which some official reticence seems to have prevailed. Among them, was no doubt, the new coal dumping appliance at The Bluff, recently installed and ceremoniously inaugurated by the Union Minister of Transport.

The apparatus is said to embody a number of novel features, which, in conjunction with its height (over 100 feet) and its weight (over 800 tons), is claimed, make it unique among coaling appliances at ports throughout the world. It was specially designed to suit the soft South African coal, with a minimum of breakage.

Its present loading capacity is not less than 1,200 tons per hour: it can handle 30 truck-loads of coal in that time and has accordingly threefold the capacity of the older types at Durban. A description of it extracted from a recent issue of *The Engineer*, is as follows:

"It works in four synchronised movements. Fully loaded trucks are moved on to the cradle by means of an electric winch. The cradle lifts and inverts the trucks so that their contents pour into a storage bin with a capacity of 250 tons. From the bin, measuring boxes are filled with seven tons of coal, each by automatic movement. The coal is then tipped into special buckets standing on flat-bottomed trucks. These trucks, known as "bucket cars," take the load to the transporter, which quickly lifts each bucket and empties the contents into the ships' bunkers. As soon as the coal is dumped, the truck is returned by the cradle, run off and another is moved into position. Every movement is a matter of seconds. When new bogies on order come into operation, the dumper will be able to handle as much as 2,000 tons of coal per hour. The dumper, which will ease the coaling position at Durban considerably, is also designed to handle manganese and iron ore."

The Durban Coal Dumper is certainly a notable example of modern coal-handling appliances, but its working capacity cannot be said to be altogether exceptional. The Curtis Bay Coaling Pier at Baltimore which has been in existence for at least twenty years, has a nominal capacity of 2,000 tons per hour over its three belts, and a similar installation at Sewall's Point, Virginia, has a maximum capacity of 2,500 tons per hour, without trimming. At the same time, it has to be admitted that these performance are for bulk loading and not for bunkering, and that, even in these cases, owing to delays from various causes, such high rates cannot be maintained indefinitely. Anything, in fact, between 1,000 and 1,500 tons per hour represents a highly creditable performance.

The Labour Party and Port Control.

The National Executive of the Labour Party have issued a Report—which in our view would be more properly described as a Manifesto—on the subject of the Post-War Organisation of British Transport. Comprehensively including in its purview all sections of transport in this country, it proposes to provide canals and docks and harbour undertakings with administrative boards to act under the general superintendence of a National Transport Authority with wide and far-reaching powers.

We have already indicated our views on the undue intrusion of officialdom into the normal activities of port affairs, and it is not necessary to repeat them here.

We reprint on a later page the text of the Report relating to inland waterways and docks so that readers may form their own

The United States Waterways Experiment Station at Vicksburg

Its Service for Harbour Improvement Problems*

By Brig.-Gen. MAX C. TYLER, Corp. of Engineers, U.S.A.
Director of the Experiment Station

As its name implies, the Waterways Experiment Station, located at Vicksburg, Miss., is a laboratory for the study of hydraulic problems arising in the maintenance and improvement of our national waterways. These problems are studied chiefly by means of small-scale models. In its eleven years of existence, the Experiment Station has tackled many of the most difficult hydraulic questions puzzling the engineers who are engaged in the improvement of rivers and harbours. The phrase " most difficult " is used purposely, since it is obvious that only those problems defying solution by rational means are subjected to model analysis.

Brig.-Gen. MAX C. TYLER.

The Experiment Station has been concerned both with flood control and navigation projects on the inland waterways of the country, and with the improvement of many of its ports and harbours. This paper will describe the studies in the latter group, which represents only a portion of the Station's activities.

In most cases the model studies have provided a practical solution for the problem studied, and in all cases they have made valuable contributions to both the hydraulic and economic aspects of the problems. For instance, the test results may save the engineer in charge of the project many times the cost of the model study by showing that the length or height of a proposed breakwater may be reduced, or that the proposed deepening of a channel will not produce the desired results. In the following paragraphs, this article will attempt to show the vital part model studies have played in obtaining the most suitable and economical plan for the development of the ports and harbours of the United States.

Origin and Organisation

In order to obtain a clear picture of the Experiment Station, a brief glimpse of its history and organisation is essential. The Station operates under the supervision of the Mississippi River Commission, its original purpose having been to assist in the preparation of plans for the control of floods in the Lower Mississippi Valley. It was for this purpose that the establishment of a hydraulic laboratory was authorised by the Mississippi River Flood Control Act of 1928. The Station was located at Vicksburg in order that it might be near the Mississippi River Commission offices.

Since the Experiment Station is an office of the U. S. Engineer Department, its work is directed by an officer of the Corps of Engineers, U. S. Army. The Director is assisted by a group of highly specialised engineers. Valuable adjuncts to the Station's organisation are the skilled craftsmen trained in the delicate construction work which goes into the building of a small-scale model.

From its genesis as a laboratory primarily for the study of flood-control plans, the Experiment Station has expanded to include investigations of every type of problem encountered in the regulation of our rivers and construction and maintenance of our harbours. Studies have been conducted for U. S. Engineer Department offices in every part of the country. Models are constructed to learn the hydraulic characteristics of proposed flood-control or navigation dams, and small-scale replicas of harbours and silt-laden rivers are built to test schemes for improving navigation channels. Models of existing or proposed harbours are used to determine the most desirable location for breakwaters. Recently the Experiment Station has been performing studies of this type for the U.S. Navy Department, and has also just completed an investigation of the hydraulic characteristics of the filling and emptying systems of dry docks.

The Experiment Station also has a soil mechanics division which is co-ordinated with the hydraulics division in a joint effort to master the elements of sail and water for the improvement of American waterways. In the soil mechanics laboratory, the foundations for dams, levees, locks, and dry docks, as well as the bed material of rivers and harbour are analysed.

Port and Harbour Projects Studied

Probably no other laboratory in this country has had the opportunity of investigating so many problems of this type. No attempt will be made to discuss each of the studies shown on the map; instead, a typical study of each type of port and harbour problem will be described. These problems are usually given the general classification of either movable-bed or fixed-bed studies. Movable-bed studies are those in which the principal problem is shoaling resulting from bed-load movement; these are often complicated by the necessity for the reproduction of tides as well as the simulation of the fresh-water discharge of rivers with their accompanying currents. Shoaling produced by the sudden deposition of silt carried in suspension is reproduced by injecting silt-like material into a fixed bed model. Fixed-bed models, which are simply concrete replicas of the prototype areas, are also used when the principal problem is tidal currents or wave action.

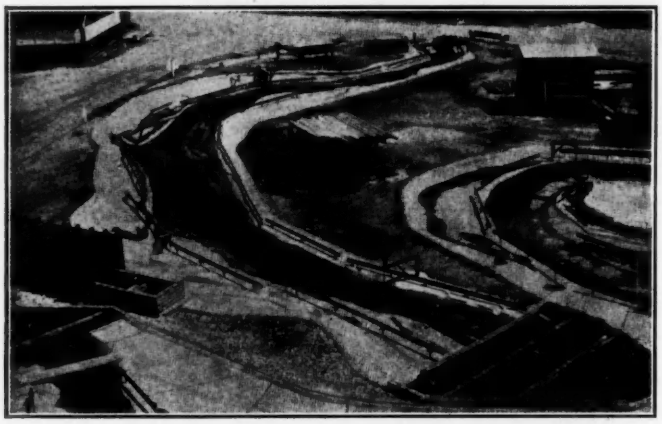
Construction of Models

Perhaps a brief description of the process of constructing a model should be inserted at this point. Before designing a model, the engineer in charge studies all available data relative to the topographic and hydraulic characteristics of the area in question. He then chooses the type of model and the model scales with a view of obtaining accurate results at the least cost. Next he lays out templates (sheet-metal pattern) of the topography of the problem area drawn to scale. These are properly placed on the prepared site, and the contours of the model are moulded of concrete to these patterns. Structures such as bridges are generally fabricated of sheet metal or wood. For movable-beds studies sized coal grains have proved to be the most satisfactory material for the simulation of river bed load; this material is spread over the model

*Paper read at a Conference of the American Association of Port Authorities and reprinted from World Ports, October, 1941.

Experimental Station at Vicksburg, U.S.A.—continued

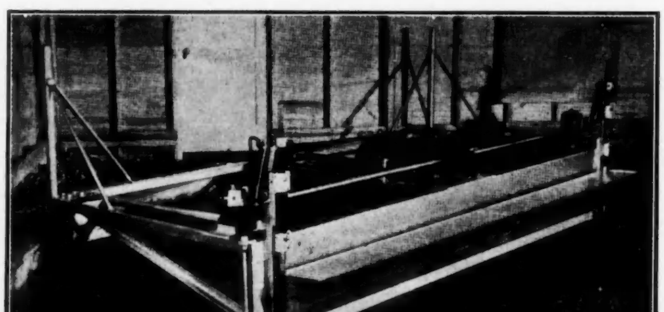
bed and moulded to prototype configurations by means of suspended templates. In silt-injection models pulverised gilsonite, a very light-weight substance, is used to simulate silt. A very fine sand is used to represent the material in beaches.



This is a River-Channel Model. Note Brick Baffles to Still Water Before it Enters the Model. Stucco is Used to Represent Channel Roughness and Wire Mesh to Represent Trees and Undergrowth. The Rails Along the Sides of the Model are Used for Taking Water-Surface Elevations.

The design and construction of model appurtenances often require as much skill and ingenuity as the building of the model proper. Provision must be made for supplying water in specified amounts, for measuring the flow through the model, and its elevation as well as velocity. For harbour models, devices have been developed for reproducing tides and waves, and for measuring and recording wave heights.

The wave-reproducing machine (see photograph below) consists of a triangular-shaped, motor-driven plunger which may be adjusted to produce a wave of any size and period. The wave-height-measuring device utilises the fact that a water path can serve to complete an electrical circuit between two points, and that if the resistance of the electrical circuit thus established between consecutive points be made to vary in direct proportion with the watersurface elevation, the resultant current changes in the electrical circuit will correspond directly with changes of water-surface elevation on consecutive contacts. This principle has been adapted to a resistance staff which may be placed at any location on a model. The device used to record the rapid fluctations of current in the resistance staff is an electric oscillograph which provides a two-dimensional graphic plot of the model waves from which the height can be scaled. This measuring and recording apparatus is being tested for field installations and it is anticipated that it will prove valuable in the collection of field data.



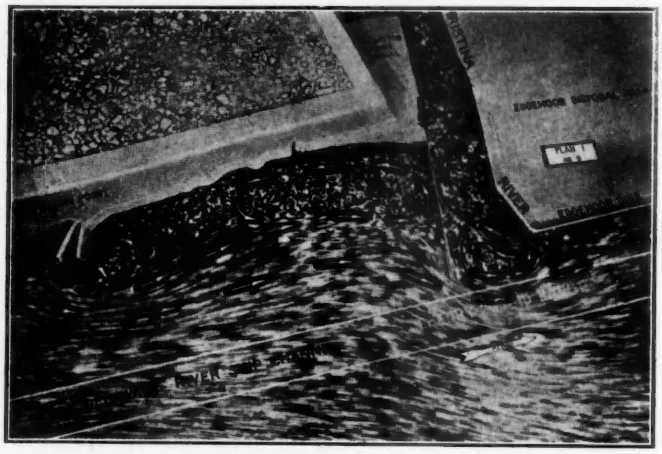
The Wave-Reproducing Machine Which Has a Wave-Height Measuring Device.

The tidal-reproducing apparatus consists of electrically operated discharge valves or overflow weirs which regulate the amount of water added to or taken from the model. These valves or weirs are controlled by a motor-driven cam which is simply a polar plot of the tide to be reproduced.

Examples of Fixed-Bed Models

Let us first consider the suspended-silt type of shoaling which is studied by means of injecting silt into fixed-bed models. A typical example of such a model is that of the Delaware River. The problem of reducing or elimating shoaling in various reaches of this river has been under consideration at the Experiment Station for several years.

The first study on this model was concerned with the shoaling problem at the entrance to the Chesapeake and Delaware Canal. Tidal fluctuations force the silt-laden waters of the Delaware River into the canal where the silt is deposited causing extensive shoaling. The entrance to the canal is protected by two 1,350-ft. jetties which have not been entirely effective in preventing the shoaling. The fixed-bed model reproduced 17 miles of the Delaware River and the eastern three miles of the canal. Tides were reproduced, and gilsonite was injected at three points to simulate the suspended silt of the river. Thirteen proposed improvements were tested covering all practicable plans for shoaling elimination by means of jetty extensions or spur jetties off the adjacent shore. As a result of these tests, an 800-ft. extension to the north jetty was recommended and is to be constructed in the prototype in the near future.



This Photograph Shows the Effect of a Jetty Plan on Current Directions at Mouth of Christina River. Confetti is Used to Indicate Current Directions.

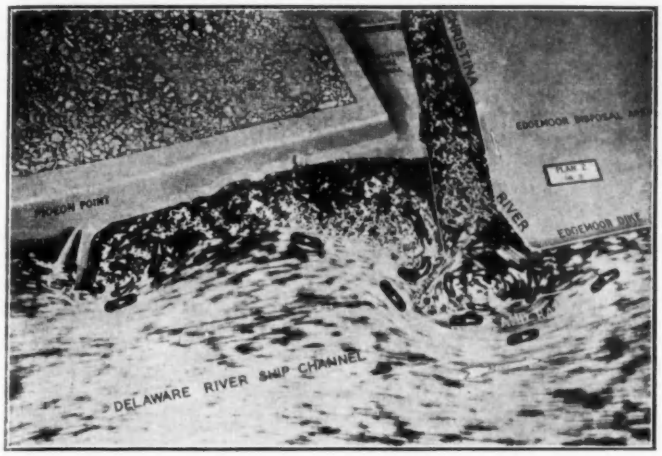
Upon completion of these tests, the model was extended for a study of shoaling conditions in Wilmington Harbour, Delaware. This harbour, located on the Christina River near its confluence with the Delaware River, is also shoaled by flood currents carrying silt from the Delaware into the harbour area where it is deposited (see photographs on this and the next page showing the effects of different jetties on currents). However, tests indicated that none of the improvement plans considered practicable would effect any appreciable reduction in shoaling.

At present this model has since been used to test plans proposed for shoaling reduction in Deepwater Point, Finns Point and New Castle ranges of the Delaware River Ship Canal. These tests are of especial importance at present because of the necessity for increasing the depths in the Delaware River sufficiently to enable large naval warships to proceed to and from the naval yards at Philadelphia.

In 1938 the Experiment Station conducted a model study of the navigation channel in East River, New York. The study was instigated by the U. S. Navy Department, which wanted to make

Experimental Station at Vicksburg, U.S.A.—*continued*

the route through East River to Long Island Sound navigable at all times in order to secure full-time access to the Brooklyn Navy Yard through Long Island Sound as well as through Upper New York Bay. The tidal waves entering East River from the Upper Bay, from Harlem River, and from the Sound produce



The Effects of Jetty Plan on Current Directions at Mouth of Christina River. Compare with View on previous page, Noting the Effects of Different Jetty Installations on the Currents.

currents which, with the existing channel conditions, present serious obstacles to ships passing through East River to the Sound. To remedy this situation it was proposed to realign and deepen the river channel.

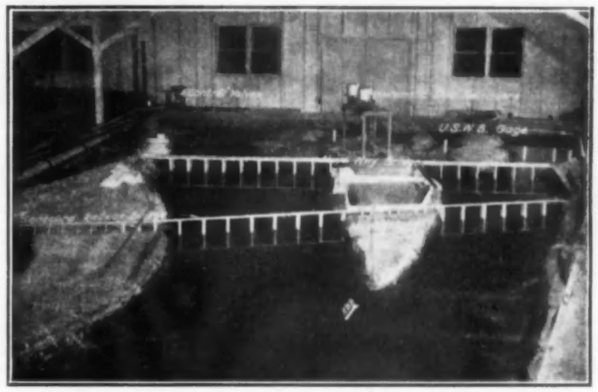
The problem, essentially one of tidal currents, was studied on a fixed-bed model equipped with tide-reproducing mechanisms. Twenty-three plans were tested and a satisfactory solution of the problem was evolved. Of interest is the fact that the plan originally proposed was shown to be ineffective, and that the most effective plan developed on the model could be constructed for about $10,000,000 less than the original plan.

As before stated, the Experiment Station has recently made several studies of breakwater locations for the Navy Department. One of these was an investigation of the best location for a breakwater to reduce wave action in the outer harbour of San Juan, Puerto Rico. A fixed-bed model of the outer harbour and a portion of the Atlantic Ocean was constructed and equipped with a wave

Wave Action in a Harbour Model.

machine and wave-height measuring gauges (photograph above shows waves in a harbour model). This study demonstrated convincingly that the only reliable method of selecting the location for any but the simplest breakwaters is by means of a model study. This was evidenced by the fact that the locations originally proposed for the breakwaters would have made these structures almost entirely ineffective.

Of interest in connection with wave problems is a study being conducted for the Great Lakes Division of the U. S. Engineer Department to determine the pressures of waves against various



View of Upper End of Richmond Harbour Model.

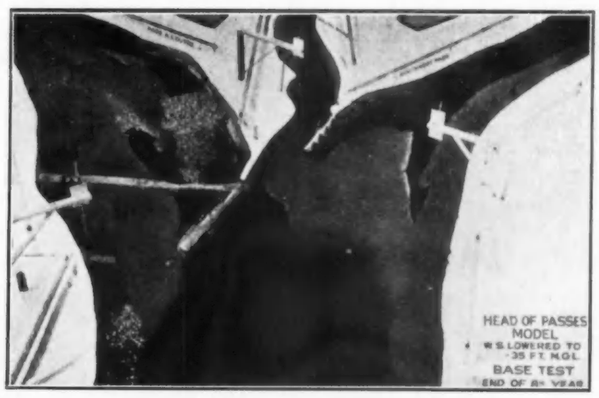
types of breakwaters. Before the testing problem could be undertaken it was necessary to develop means of measuring and recording the pressures exerted by waves. A device had been perfected which consists essentially of a pressure-responsive electric gauge head set into the structure and connected to an amplifier which is in turn connected to an oscillograph. This device is very satisfactory for obtaining records under any desired conditions.

Example of Movable-Bed Studies

An example of a movable-bed study complicated by tidal action is the problem at Richmond Harbour, Va., located at the head of tidewater on the James River. The upper end of the harbour is, in effect, a sediment basin since here the flows from the steep upper river meet the relatively level pool at the head of tidewater. As a result, rapid shoaling occurs and the project channel is maintained with difficulty by means of frequent dredging.

A movable-bed model of the critical area was constructed, and means were provided for supplying and measuring any desired fresh-water discharge, and for the automatic reproduction of tides and the resulting tidal currents.

Eight improvement plans were tested, consisting mainly of contraction works or the removal of rock from the channel bed to permit of dredging to greater depths. However, the tests results



Critical Area at Head of Passes, Mississippi River. Model Drained to Show Shoals.

indicated that none of the improvement plans would solve the shoaling problem, and, in fact, that the contraction works would tend to increase flood heights slightly. A continuation of the program of periodic dredging appeared to be the most feasible

(Concluded on page 69)

The Hydraulic System of Operation as applied to Dock Machinery

A Survey of Modern Developments and Adaptations

By C. H. NICHOLSON, M.I.E.E., M.I.Mech.E.,
The Docks Machinery Engineer, London and North-Eastern Railway.

General Description

THE hydraulic system, which has been in use for many years, was upon its inception, primarily a means of transmitting power produced by steam driven pumping stations, and in view of the fact, that electrical transmission was, at that time, in the evolution stage, hydraulic power was therefore transmitted over relatively large distances.

With the present availability of electric power from public undertakings, the utility of the hydraulic system is somewhat modified, as the losses incurred in electrical transmission are less, provided that an economic voltage is selected, depending upon the distance of transmission and the power to be transmitted.

The above consideration suggests centralising the sites of pumping stations with respect to the appliances to be supplied with hydraulic power, and using electric power for the purpose of driving the pumps. Under these conditions, relatively short hydraulic mains, having a high velocity flow and hence minimum diameter, may be used.

Generally, the area served by a single pumping station should not be large enough to incur excessive losses, or conversely large pipe diameters, and in practice, this may be regarded as an area having a radius of from 1,000 to 1,500 yards when the working pressure approximates 850 lbs. per square inch, corresponding to a flow velocity of six feet per second, and a pipe friction loss of 10 per cent. approximately.

The ideal hydraulic installation is, therefore, one in which electric power is supplied to a number of automatically-controlled pumping stations, within the area to be served, and sited to conform with the above limitations.

The general scheme of the hydraulic system is shewn diagrammatically in Figure 1, an electrically driven ram pump being fed on the suction side from an overhead tank, an accumulator controlling the pump and also acting as a reserve during peak demands. From the accumulator, a main serves the appliances, hand-operated control valves regulating the flow of water, hence the speed of the appliances.

After the water has given up energy to the appliances, it is returned to the overhead tank by means of the return main, the necessary pressure to accomplish this being provided by the weight imposed by the appliance rams, counterweights or constant pressure rams, e.g., in the case of a direct acting hoist, upon opening the exhaust valve to the return main in order to lower the wagon table, the weight of the ram and table forces the water out of the cylinder into the return main.

Some years ago, the layout of pumping stations allowed for the provision of a return water well at ground level with the object of reducing return water main pressure, low pressure pumps being utilised to lift the return water from the level to the overhead suction tank. Modern practice dispenses with the low level well, the return water being delivered directly to the overhead tank. In order to provide for the making up of losses due to leakage in the system and appliances, a fresh water supply is provided at the suction tank, which, in order to give a reasonable reserve, should have a capacity equivalent to the maximum demand upon the station over a period of from 20 to 30 minutes. Return mains should have an area approximately 25 per cent. to 50 per cent. greater than the pressure mains, general practice being, up to six inch diameter pressure mains, to make the return one inch larger in diameter.

Where large quantities of return water may be delivered over short periods, as in a number of large coal hoists, surge tanks are sometimes provided on the top of the hoists to reduce the peak pressure.

The pressures adopted for the operation of dock appliances are between the limits of 600 lbs. per square inch and 1,100 lbs. per square inch, with the majority of dock systems utilising pressures of from 750 lbs. per square inch to 850 lbs. per square inch. The load factor varies from 5 per cent. to 30 per cent. under average working conditions and the diversity factor from four to seven.

Characteristics

For the operation of dock machinery, where linear motion over a specified distance against load is required, as in the case of cranes, coal hoists, dock gates and tipping appliances the hydraulic system has many advantageous features which may be enumerated as follows:

few working parts (hence reduced maintenance), reliability robust construction, acceleration and deceleration are infinitely variable, dependent only upon the position of the operating valve; braking is automatic, generally without the use of additional devices, the overload capacity is inherent, depending upon the area of the ram and the pressure relative to the load, very low creeping speeds are obtainable without the use of complicated control devices, it is in consideration of the above that the hydraulic system should be regarded rather than as a means of power transmission.

Rotary appliances suffer from the disadvantages of low efficiency, mainly due to loss in the working valves; in the case of capstans however, in view of the fact that the actual working time is relatively small, this disadvantage is compensated for to a great extent by reliability and the inherent overload feature.

Generally, the disadvantages of hydraulic machinery are as follows:

the consumption of pressure water, and hence power, is independent of the load imposed upon an appliance, being under all conditions, equal to that required for full load plus the designed overload.

This disadvantage may be mitigated by the use of either multiple or telescopic rams, the small rams being brought into operation for light loads. Where other forms of power are available from a public undertaking, the cost of providing pumping stations increases capital costs. Considerable damage may be caused by frost, but with carefully designed drainage, together with the provision of heating, this can be obviated.

It is not suitable for appliances which are required to travel frequently over relatively large distances whilst in operation.

The essential details of the hydraulic system are accumulators, mains, valves, cylinders and rams, sheave multiplying gear (commonly referred to as jiggers), hydraulic engines, pumps, low level and overhead suction tanks.

Accumulators

An accumulator consists essentially of a vertically mounted cylinder provided with a loaded ram, the load being made up of cast iron weights, sand, slag or other heavy material contained in a sheet steel canister attached to the ram crosshead by vertical bolts, the ram stroke is usually from 20 feet to 36 feet and the diameter of the ram varies from 17-ins. to 22-ins. for pressures of 700 to 850 lbs. per square inch.

The Hydraulic System of Operation as applied to Dock Machinery—continued

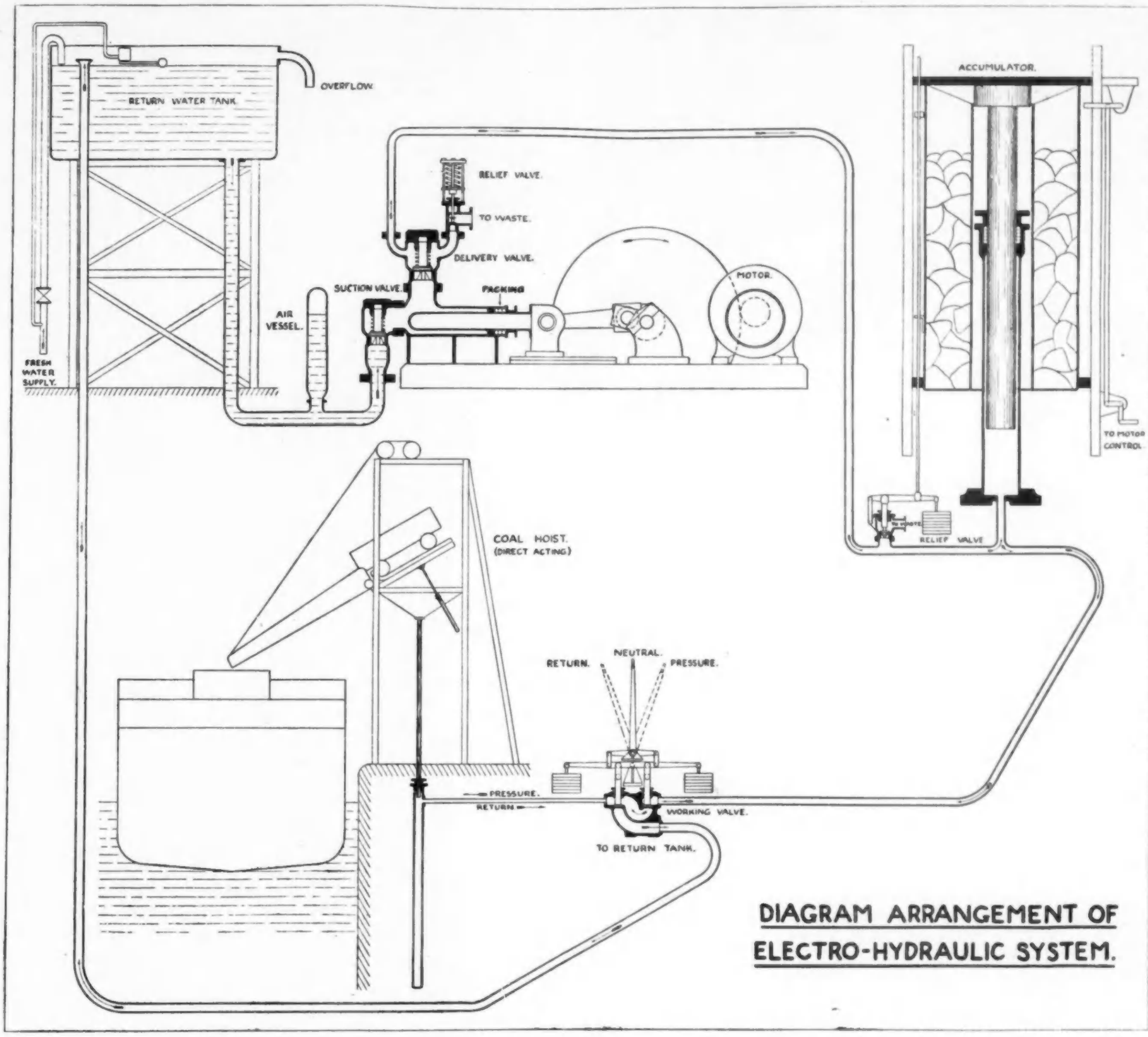


Fig. 1.

The ram and cylinder are of cast iron, long stroke rams often being made in two parts with spigot joint secured by dowels or screwed joint stops being provided to prevent any possibility of the ram being forced out of the cylinder.

Vertical guides fixed to the accumulator house (or, alternatively to the structure in accumulators installed without housing), in conjunction with shoes attached to the ram crosshead engaging the guides, ensure vertical alignment of the ram throughout the entire stroke.

The function of an accumulator is to provide a reserve of hydraulic power serving sudden peak demands, act as a shock absorber, and smooth out pump pressure fluctuations, the ram displacement in a three throw single acting pump varying as three harmonic motions displaced by 120 degrees. Probably one of the most important functions, however, is to act as a controlling agent for the pumps at the station, to ensure that the pumps are only called upon to operate under maximum efficiency conditions, this being dealt with at length later.

In order to provide a reserve of hydraulic power, accumulators are often installed distant from the pumping station, being connected directly to the pressure main and situated adjacent to the point where there is the largest demand, e.g., near to a number of large coal hoists. In this case, the loading of the ram is less than that at the pumping station, otherwise the ram would not rise, owing to the mains pressure drop. It is of interest to note that the energy storage of an accumulator having a 22-ins. diameter ram and 33 feet effective stroke working at 850 lbs. per square inch is approximately 5 h.p. hours. This is apparently small, but when the period of a peak demand is considered it represents appreciable power available, e.g., if the demand is of one minute duration, the accumulator is capable of delivering 300 h.p.

Chain-operated ultimate limit relief valves and momentum valves are provided as standard practice.

The efficiency of accumulator approximating the capacity indicated above is in the range of from 93 per cent. to 97 per cent.

Examples of accumulators are given below:—

Ram diameter	**22-in.**	**22-in.**	**7½-in.**
Stroke	**36-ft.**	**33-ft.**	**12-ft.**
Pressure	**800 lbs.**	**800 lbs.**	**1600 lbs.**
Loading	**135 tons**	**135 tons**	**32 tons**
Power Storage over 1 min. ...	**330-h.p.**	**300-h.p.**	**25.6-h.p.**

The Hydraulic System of Operation as applied to Dock Machinery—continued

MAINS (Pressure and Return)

For hydraulic purposes pressure mains are rarely larger than 7-in. in diameter, usually of cast iron or steel, manufactured in units of 9ft. in length in cast iron and up to 30-ft. in steel.

The standard flange joint is oval, cast integral with the pipe, or in small pipes or steel pipes, cast separately and screwed, one flange being provided with a spigot and the other a faucet, the joint being made by means of a circular ring of gutta percha cord.

Return mains are made with socket joints and should be approximately 25 to 50 per cent. larger in area than pressure mains serving the system.

Operating Valves. (Fig. 2)

Valves of the mitre type are used where high speeds are required as for crane, hoist and tipping platform lifting motions, one valve to control the inlet and one for the exhaust being provided. The valve box may be of cast iron or gun metal and is usually fitted with renewable gun-metal screwed-in valve seats; suitable link motions connect the valves to the operating levers.

D-slide valves are used for crane luffing motions, slewing motions, chute operating gear etc., and are essentially similar to steam slide valves. The valve and seats are usually of hard gun-metal and have two ports for controlling a single hydraulic ram.

Piston valves are an alternative to slide valves and have two advantages over slide valves, in so much that they are easier to operate, and cannot be forced off their seats by pressure surges.

When the operating pressure is high and the valve large, D-slide valves require considerable effort to operate them due to the pressure on the valve faces. To minimise this, water shot relay valves may be used. This valve consists of a small slide valve which, when operated, allows the pressure water to pass to either end of a piston, which, in turn, moves a large slide valve into the required position.

Large mitre valves over 2-ins. in diameter require considerable effort to operate them, and therefore are usually of the balanced or pilot type.

Relief Valves

Mitre valves held upon their seats by means of springs are used for the purpose of protecting mains, pumps and appliances against the effects of pressure surges. Similar valves operated by levers and chains are used for the purpose of relieving accumulator pressure when the limit of the working stroke is exceeded.

Momentum Valves

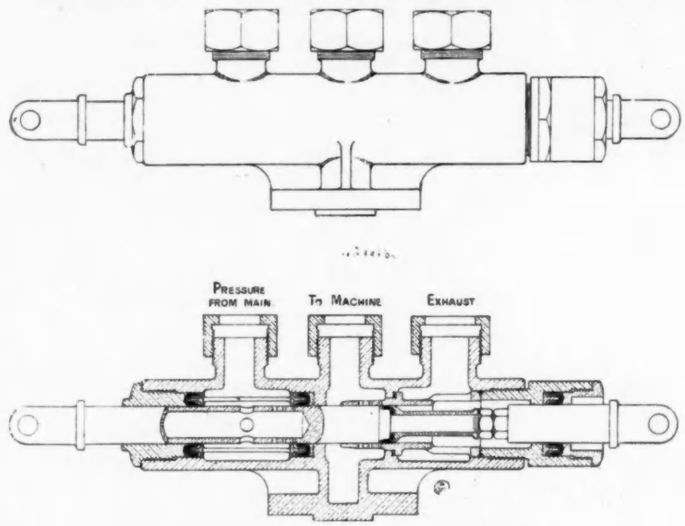
These valves consist of a chamber and piston, the latter rising against the pressure of a spring when the mains pressure becomes excessive due to surges.

Non-Return Valves

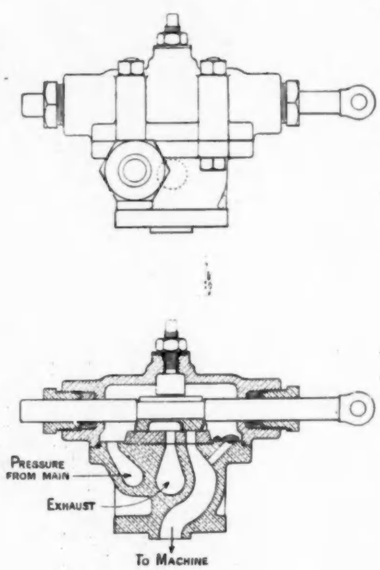
In order to prevent pressure water flowing from the accumulator into turbine type pumps or appliances passing intensified pressure into mains, back pressure or non-return valves are used. These are stop valves in essentials but fitted with a loose springloaded valve which closes upon back pressure.

Bye-Pass Valves (for Use with Ram Pumps)

A bye-pass valve consists of a piston or electrically-operated valve for hydraulic or electric operation. It is used to bye-pass pressure water from the delivery side of a pump to the suction side during the starting period, the valve being closed when the pump attains full speed. By this means, the pump has virtually no hydraulic load upon it during the period of acceleration. Stop valves are of the mitre type, operated by means of a screw thread and balanced in large valves.



The Hydraulic Eng. Co., Ltd., Chester.



Piston Valve. Fig. 2. Slide Valve.

Sheave Multiplying Gear (Jigger). (Fig. 3)

As the travel of the lifting motion of a crane or coal hoist may approximate 100 feet, it is convenient to design the lifting ram with a stroke much less than this and multiply the stroke of the ram by a system of sheaves. The lifting rope is anchored to the cylinder at one end, passes around the sheaves and is finally attached to the crane hook or, the lifting table of a hoist for example.

The arrangement is essentially the same as a normal rope block, but operates in the reverse direction, the travel of the rope being increased, and the pull upon the rope being decreased in the ratio of the multiplying power; e.g., a quayside crane requiring a total travel of the hoisting rope of 72 feet is usually designed with multiplying sheaves giving a six to one ratio, the lifting ram stroke being 12 feet. If the capacity of the crane is three tons, the ram pressure is obviously 18 tons, plus the pressure required to overcome friction.

The above arrangments may be regarded as the working mechanism of all cranes and hoists, and has much to recommend it upon the score of simplicity.

The mechanical efficiency is dependent upon the multiplying effect, being less the greater the number of sheaves, and having a value of approximately 74 per cent. for a multiplying ratio of

The Hydraulic System of Operation as applied to Dock Machinery—continued

six. Jiggers may be of single power, i.e., having a single ram and cylinder, or multi-power, having two or more rams and cylinders of differing sizes, the small rams being used for light lifts. A variation of this principle is a single cylinder having two rams, the smaller working inside the larger hollow ram and referred to as a telescopic ram. When lifting light loads, the large ram is locked in position by means of links and a manually operated lever.

Hydraulic Engines

These are used for the purpose of driving rotary machinery, such as capstans and the slewing and travelling motions of large

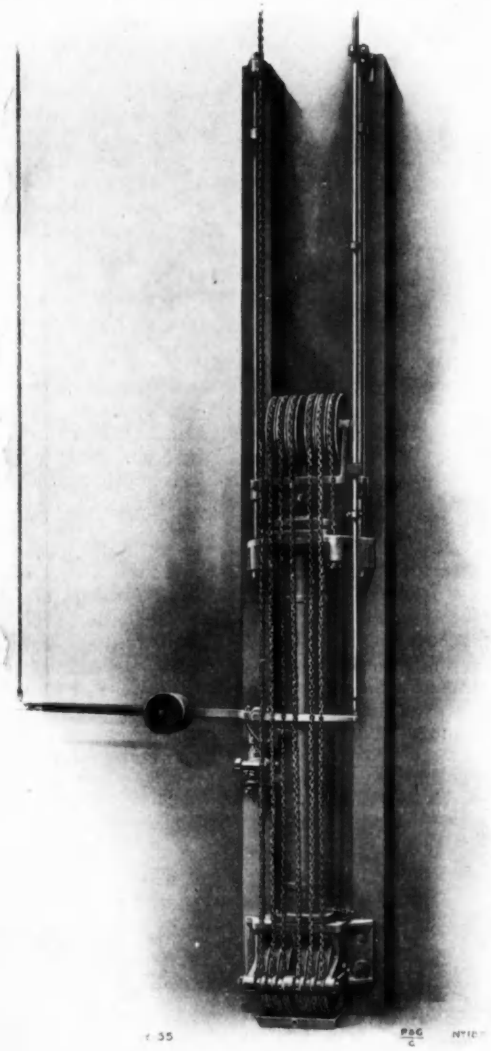


Fig. 3.
The Hydraulic Eng. Co., Ltd., Chester.

cranes. The horizontal two-throw engine has two crankshafts, displaced 90 degrees from one another. Two cylinders, having rams fitted with crossheads working in slides, carry the crankshaft connecting rod, pressure water admission and exhaust to the cylinders being controlled by D-slide valves, operated by an eccentric mounted upon the crankshaft. This type is now practically obsolete.

Modern capstan engines are designed with three cylinders set at 120 degrees to one another. Two general types are in use: (1) the Brotherhood in which the cylinders are fixed and fitted with pistons and connecting rods terminating in shoes, transmitting the piston movement to a common crankshaft. A three-port rotary valve fixed to the crankshaft regulates admission of pressure water to the cylinders. The Armstrong type is designed with oscillating cylinders carried upon trunnions, each ram having a shoe cast integral with it, all shoes acting upon a single crankshaft. The valves regulating admission and exhaust are of the oscillating type, one per cylinder. The full load efficiency of the rotary hydraulic engine is relatively low, being about 55 per cent. on a working pressure of 850 lbs. per square inch. At loads of less than full load, the efficiency is extremely low, as the quantity of pressure water used is independent of the load.

Cylinders, Glands and Ram

Cylinders are of cast iron or, in modern ram pumps, steel forgings. As the ram is not in contact with the inner surface, machining is only necessary for the gland and neck ring landing, except where double acting rams are fitted, which have cup leathers or packing which act in the same manner as a piston. Where the gland is sealed by means of fabric, hemp or leather packing, the gland should have sufficient depth to accommodate six rounds of packing. "U" and "L" leather packing rings require less gland depth, but have the disadvantage that the ram must be withdrawn to repack. Below the packing, a bronze neck ring acts as a bearing surface for the ram and support for the packing.

Rams are of cast iron, stainless steel, or cast iron or steel, shrouded with phosphor bronze, the latter giving extremely long service and being used mainly in capstans and ram pumps, or for small rams where the operations over a given time are large in number. Constant pressure rams for the purpose of returning the operating ram when the cylinder of the latter is opened to exhaust, as in the luffing motion of a crane, may be hollow and of phosphor bronze or steel.

Average ram speeds in practice are as follows :

Steam-driven Pumps	200/300 feet per minute
Electrically-driven Pumps	120/180 ,, ,,
Cranes...	40/ 80 ,, ,,
Large Coaling Cranes, 25/30 tons capacity	5/ 10 ,, ,,
Coal Hoists	80/120 ,, ,,
Capstans	60/150 ,, ,,

Gland Packings. (Fig. 4)

These are for the purpose of forming a seal and thus preventing leakage at the gland. Frequently, greased plaited packings are

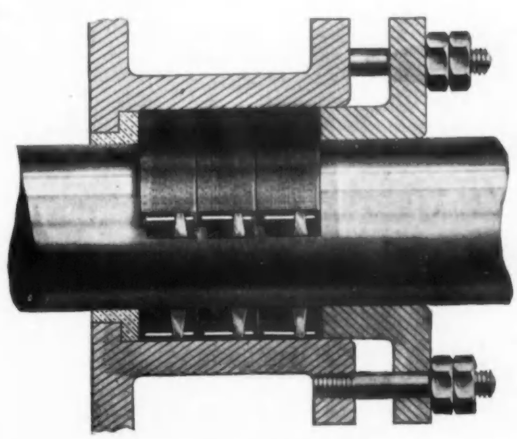


Fig. 4.
Messrs. James Walker & Co., Ltd., Woking.

used, but these rely mainly upon gland-pressure to form a seal, thereby creating friction.

More efficient types are automatic in action, the pressure itself operating upon the packing to form a seal, and for high pressures

The Hydraulic System of Operation as applied to Dock Machinery—continued

these are in general use, and for pressures up to three tons per square inch are most essential. Two well-proved types are the "Automatic" and "U" section rings. Both require to be fitted true to size and are manufactured from rubberised fabric, designed to ensure expansion by the pressure medium, rubber being an important essential as a waterproofing and binding agent.

In the two types referred to, expansion of the packing is very limited, due to processing of material in construction, the seal being formed by the "U" or lip formation. With "Automatic" packing, the lip is moulded on the working face, and it is this lip which is expanded by the working pressure. In addition, the face is studded with Antifriction Metal Pins, set at an angle of 45 degrees, and so spaced that they overlap one another and present a continuous bearing surface which reduces friction. "U" section rings are endless, and therefore present a difficulty in fitting on many types of hydraulic plant. The "Automatic" type is supplied as split rings which facilitate fitting, and a minimum of three rings is necessary to ensure an efficient seal. In operation, the pressure medium enters the open end of the "V" forcing out the lip against the moving ram. Any leakage passing the first ring is held by the next.

The "Automatic" type is the most efficient for accumulators and large rams in general, whilst the "U" fabricated rings may be fitted to capstans, etc., where single endless rings must be fitted.

It will be understood that the two types of packing referred to cannot give complete satisfaction on worn rams, where it is advisable to use greased plaited packings.

(*To be continued*)

Publications

The **Journal of the Engineering Society** of University College, London, for 1943-44, continues the record of the work of the Engineering Department at present in Swansea (where it has been for the past five years) and announces its impending return in October to Gower Street. There are a variety of articles, mainly, of course, of engineering interest, but not specially associated with the sphere of dock and harbour engineering.

The Timber Development Association, Ltd., have issued a useful little booklet on **The Fireproofing of Timber.** The term is not precisely accurate, since timber is susceptible in any condition to the action of fire and, in fact, no material is immune from deterioration; even such resistive substances as concrete and stone disintegrate when exposed to heat considerably below the temperature of a burning building. All that can be done in the case of timber is to produce a condition of high resistance to fire, or perhaps, more exactly, a condition of fire retardation.

The booklet provides useful information about the combustibility of different kinds of timber which are set out in order in an Appendix. The process of combustion is described and the agencies are explained by which it may be retarded, including chemical treatment and surface coatings.

There can be no question about the importance of the subject, especially in view of post-war reconstruction plans. The Association are prepared to supply a copy of the booklet to anyone who sends a penny stamp for postage. The address of the Association is 75, Cannon Street, London, E.C.4.

Brujula is a Spanish pictorial review, published on the 1st and the 15th of each month (2.50 pesetas). Through the courtesy of the British Council we have received a copy of the issue for the 1st of June. Its sub-title: On the Eve of Invasion, sufficiently indicates the nature of the contents which have little in common with those of this Journal, being practically illustrative of the hostilities in progress and kindred naval topics, though there are one or two minor articles on the fishing industry in Spanish waters including the sardine fishery.

South African Port Facilities

Report of Government Commission

A Government Commission, known as the South African Shipping Commission, issued a few months back an interim report on the conditions at present affecting the shipping services of the Union. It embodied recommendations in regard to port facilities at the disposition of the coastal trade, and on the question of port dues. The section of the report in question, which naturally concerns the South African port authorities, is as follows:

Port Facilities

"We were told by those witnesses who spoke on behalf of the coastal shipowners that one of the principal difficulties under which coasters operated is the lack of special berthing facilities at Union ports. They illustrated their contention by citing the apparent preferential treatment accorded to mail ships. The fact is that fixed berths are not allocated for the exclusive use of mail ships, but on account of their draught and having regard to the special nature of the cargoes carried it is customary for these vessels to occupy the same berth at any particular Union port. This, however, does not apply to other ocean-going vessels visiting Union harbours. There seems to us to be some justification for the representations of the coaster shipowners in this matter and certainly they should be under no avoidable disabilities in their use of the ports. As far as practicable, endeavours should, we think, be made to provide berthing facilities for ships operating regular coastwise services at least equal to those enjoyed by the ocean-going ships.

Shipping and Port Dues

"We listened carefully to representation on this point also, but after examining minutely the facts, we have come to the conclusion that the dues and charges at Union ports are not, in any case, sufficiently onerous to make the introduction of this form of preference effective, if that policy were to be adopted. Furthermore, we should point out that the tariff of dues and charges applicable to harbours controlled by the South African Railways and Harbours Administration already provides a measure of relief to ships engaged in the coasting trade. In Clause III (j) of the Tariff it is stated that "ships engaged solely in the coasting trade between the limits of Walvis Bay and Beira having paid port dues eight times within the current year at any of the principal harbours are exempt from further payment of port dues at that harbour for the remainder of such calendar year." The dues payable at the minor harbours are on a different and lower scale to those applicable to the major ports.

Customs Duties on Ships' Stores

"Another contention by the owners of Union coaster services was that they were at a disadvantage as compared with ocean-going vessels in not being able to purchase ships' stores, except under payment of duty. They had, for instance, to purchase engine-room, deck and cabin stores at prices which included duties imposed by the Union Government, whereas ocean-going vessels were in the position of being able to use duty-free material and stores immediately they were outside Union territorial waters. When we came to examine this matter in detail we found that in actual fact very small sums of money were involved, and the witnesses in question, as well as the Commissioner of Customs and Excise, Mr. C. E. Saunder, who was good enough to give evidence before us on this and other matters, agreed that this was so.

Conclusion

Summing up on these points the Commission say:—

"Our deliberations under this head have led us to the conclusion that the adoption of any form of port tariff discrimination would bring only minor benefits to Union shipowners, while at the same time tending to irritate and antagonise the owners of foreign ships. In the event of foreign-owned liner services being withdrawn from the Union coastwise service, the probability is that the coastwise freights would tend to increase."

Notes of the Month

Death of Conservancy Official.

The death is announced, in his 61st year, of Mr. H. J. Berkwith, who was for 32 years marine superintendent of the Tees Conservancy Commission.

Dublin Port and Docks Board.

The chairman of the Dublin Port and Docks Board has tabled a a motion for the consideration of the Board "that the best interests of the undertaking would be served by the appointment of a Port Board manager."

New Port Manager at Gothenburg.

The Gothenburg Harbour Board, Sweden, has appointed Capt. Gunnar Osvald to be manager of the port. The appointment is to date from September 1st next. Since 1934 Capt. Osvald has been managing director of the Swedish Ships' Officers' Association.

Erratum.

A correspondent has kindly pointed out a typographical error in the April,1944 issue. On page 271 (Port District of Keihin) lines 9 and 10, "ft." and "ins." should read "mins." and "secs." respectively, thus: 35 degrees 24 mins. 42 secs. and 139 degrees 40 mins. 10 secs.

Repairs to Clyde Tidal Weir.

Glasgow Corporation has agreed to spend nearly £90,000 on repairs to the damaged portion of the tidal weir on the Clyde. This river barrier was erected some 40 years ago at Glasgow Green and serves to maintain the river level for about three miles up stream. It is contended that any deterioration in the conditions would result in the period of high water in the navigable channel being reduced by 45 minutes to the detriment of shipping.

Future of Plymouth Harbour.

The future of the port and harbour of Plymouth is discussed in the report recently prepared by Professor Abercrombie and Mr. Watson, the City Engineer. They express the hope that fishing, which, in their opinion, was probably the origin of the town may be revived as a staple industry. Various alterations are proposed in the existing layout and developments in the dock accommodation are indicated.

Proposals for Port of Swansea Development.

In a recent report by the Swansea Chamber of Commerce to the Swansea Council Development Committee are recommendations for increased cold storage accommodation near the docks; reclamation of land beyond Queen's Dock for more dock accommodation; increased dry dock facilities; improvements in oil and coal bunkering; uniform flat road and rail haulage rates on import and export general cargo traffic; a more reasonable dock charge basis as between South Wales and the larger United Kingdom ports and comprehensive inclusive handling rates for all classes of goods.

Tug Salvage in Sydney Harbour.

An interesting case of craft salvage within harbour waters is reported from Sydney, New South Wales. In 1940, the 57-year old tug *Hero* sank in consequence of collision with a freighter and remained submerged for a considerable period. Early in 1943, it was decided to attempt to raise the vessel and the work was entrusted jointly to the United States Navy and Army local staffs.

Balloons were used to provide flotation. Owing to the depth of water in which the vessel was lying, there was considerable difficulty in making attachments to the hull. Divers could only work 45 minutes at a stretch, and the process of bringing a man to the surface in safe stages occupied two hours.

Eventually, the vessel was raised to within 30 feet of water surface level; she was then towed to a dry dock, pumped out and the holes in the hull plugged. This done she was taken to a repair wharf at Balmain.

New Grain Elevator at Canadian Port.

A contract has been awarded for a grain elevator at the port of Hamilton, Ontario, with a storage capacity of 1,325,000 bushels.

Knighthood for former Docks Manager.

Amongst the recent Birthday Honours is included a Knighthood for Mr. Eustace James Missenden, O.B.E., General Manager of the Southern Railway. It will be within the recollection of our readers that Mr. Missenden was at one time Docks and Marine Manager at Southampton. A biographical sketch appeared in the issue of October last.

Congestion Relief Measures at Rio de Janeiro.

Congestion in the dock warehouses at the Port of Rio de Janeiro has caused the Port Administration to take the matter up with the Associaçao Commercial. Instructions have been given to remove all goods which it is possible to store in the open. The cost of removal is to be charged to the owners or consignees of the goods.

Glasgow and the Scottish Ship Canal Project.

The Special Committee of Glasgow Corporation on Post-War Planning has decided to take no action in connection with the proposed mid-Scotland ship canal. This recommendation is made to the Corporation after receiving from the Town Clerk a copy of a memorandum he had prepared, which gives the history of various negotiations, discussions and reports concerning the project.

Port Utilisation Committee in U.S.A.

It is announced that the United States War Shipping Administration have formed a Port Utilisation Committee to co-ordinate the various activities connected with the movement of ocean freight in order to avoid congestion in United States ports and to provide for the most effective use of port facilities. In addition to representatives of the Army, Navy and the office of Defence Transportation, the Committee comprises the following:—Chairman: Captain Granville Conway, Associate Deputy Administrator; Mr. W. S. MacPherson, Assistant Deputy Administrator for Ship Control; Mr. G. H. Helmvold, Assistant Deputy for Ship Operations; The Director, Division of Allocations.

The National Association of Port Employers.

Mr. J. B. Jenkins, of Swansea, has been appointed the first full-time secretary of the recently-constituted South Wales group of the National Association of Port Employers. His headquarters are at Cardiff, where he commenced his duties on June 1st. Through the local port labour associations, at each of the South Wales ports, Mr. Jenkins will be concerned with the arrangements as to wages and working conditions of dockers at Newport, Cardiff, Penarth, Barry, Port Talbot, Swansea, and Llanelly. For the past seven years he has been secretary and transport officer of the Joint Transport Committee of the South Wales Steel and Tinplate Associations.

Death of Former Port Official.

Mr. E. C. Stuart Baker, C.I.E., O.B.E., J.P., who retired in 1925 from the position of Chief Police Officer of the Port of London Authority, has died at the age of 79. He was an experienced traveller and big game hunter, as well as an ornithologist of note, having written several books on birds, including one on cuckoos, of which he made a special study. Prior to his engagement with the Port of London Authority, Mr. Baker was Deputy Inspector General of India Police. His special task in London was the re-organisation of the Port Authority's Police during 1912 and following years. After his retirement from port duties, Mr. Stuart Baker took a great interest in municipal affairs and served as Mayor of Croydon.

Correspondence

To the Editor of "The Dock and Harbour Authority."

Electric versus Hydraulic Quay Cranes

Dear Sir,—

I am much obliged for the care Mr. Nicholson has taken in preparing the figures which appear in your May issue, as I feel that they are a useful source of reference: moreover, for any one who is interested, most of the answers to pertinent questions can be found in a study of the calculations.

Mr. Nicholson's letter of December 4th, 1943, inferred, somewhat unfairly I thought, that in the matter of acceleration the electric crane suffered from a disability compared with the hydraulic, and it seemed to give too much prominence to the influence of the hook load. The object of my reply was to indicate that lack of acceleration is not a drawback to an electric drive, and that the load of the hook does not contribute noticeably to the inertia of such a drive.

We are clearly agreed on the latter point, but I am not certain how far we can travel together upon the first, although I consider that Mr. Nicholson's own figures support my view. His acceleration of 6.6 seconds (which should be 6.1 seconds from his equation) with load is obtained utilising only 25 per cent. overload on the motor; this is probably all that is needed at any time when the crane is handling its full capacity, but is not an expression of what the *motor* is able and designed to do. As suggested in my letter 60 per cent. overload is normal and would provide three seconds acceleration, using Mr. Nicholson's figures for the machinery; again, although completely unnecessary in practice, the two seconds acceleration is there for the asking if the motor is a good one; at 720 r.p.m. there is no reason why 250 per cent. pull-out torque should not be provided by the motor maker and in that case 200 per cent. average accelerating torque for two seconds is harmless and requires current only in proportion to the torque (approximately). One can also look at this from another angle and say that there may be some advantage in having a good acceleration when the hook is empty; the normal figure of 160 per cent. torque during starting will then bring the hoist up to full speed in about 1¼ seconds.

For the hydraulic crane it seems probable that the acceleration would be approximately the same regardless of load, owing to the effect of the piping losses, valves and possibly the inertia of the water in the pipes. That is no disadvantage either, as no doubt it is advisable to prevent the driver from tearing bundled loads or sacks.

Yours faithfully,

RICHARD A. WEST, A.M.I.E.E.

The Igranic Electric Co., Ltd.,
Glasgow, C.2.

24th May, 1944.

The above letter has been submitted to Mr. Nicholson, who has replied as below:

To the Editor of "The Dock and Harbour Authority."

Dear Sir,

In reply to Mr. West's letter of the 24th May, I am pleased that the data submitted has been of interest and greatly appreciate Mr. West's endorsement.

In order to clear up the slight misapprehension indicated in the second paragraph, I have slightly modified the Anderson formula to the form:—

$$t = \frac{S}{(T_2 - T_1) \times 5.5 \times k}$$

T_2 being allowable per cent. torque on motor.
T_1 being actual per cent. torque due to load and/or friction.

Taking the three-ton electric crane at 200-ft. per minute with a load of three tons at the hook and allowing an overload of 60 per cent. upon the motor,

$$t = \frac{546}{(160 - 100) \times 5.5 \times .5} = \frac{546}{165} = 3.3 \text{ secs.}$$

With no load at the hook and allowing 60 per cent. overload upon the motor,

$T_1 = 100 - 72$, 72 per cent. being the mechanical efficiency of the crane, giving 28 per cent. as friction torque,

$$t = \frac{526}{(160 - 28) \times 5.5 \times .5} = \frac{526}{363} = 1.45 \text{ secs.}$$

Assuming a pull out torque of 250 per cent. and allowing 200 per cent. torque for acceleration with three tons at the hook,

$$t = \frac{546}{(200 - 100) \times 5.5 \times .5} = \frac{546}{275} = 1.985 \text{ secs.},$$

all of which is in fair agreement with Mr. West's calculations.

In the case of the hydraulic crane, if the pressure at the cylinder is maintained, acceleration with full load can be accomplished in approximately one-half second. Whilst such acceleration is in almost all cases entirely unnecessary and undesirable, this does in my opinion, indicate that in respect of acceleration the hydraulic crane is in no way inferior to the electric crane, this being the point I set out to prove, and not that the hydraulic crane is superior to the electric crane.

The statement made in the last paragraph of Mr. West's letter is correct, except that the question of damage does not arise, owing to the extremely fine degree of control of acceleration obtainable, creeping speeds of from 10-15 feet per minute upon a hydraulic crane having a maximum speed of 250 feet per minute being quite easily obtained with standard valve gear, with the reservation, of course, that care in operation on the part of the driver is the ruling factor.

Yours faithfully,

C. H. NICHOLSON,
Docks Machinery Engineer.

Chief Mechanical Engineer's Dept.,
L.N.E.R., Hull.

June 2nd, 1944.

To the Editor of "The Dock and Harbour Authority."

Electric versus Hydraulic Quay Cranes

Dear Sir,

Re Mr. Nicholson's letter and figures of April 6th, in your May issue. I am obliged for his information as to the method of testing used and am satisfied as to the reliability of the results, particularly as checked by tachometer.

I cannot find the Anderson paper he quotes in the Index of the I.E.E. Journal, volume 90, part 2, and there are one or two items of his figures the derivation of which is somewhat obscure, but on the whole the figures seem reasonable and acceptable. The kinetic energy figures of his electric crane work out surprisingly high and this is partly because the rotor diameter of his motor at 18-in. is very large. A standard 60 b.h.p. 1-hr. rated 3-phase slip-ring induction motor of 730 revs. has a rotor of 13-in. diameter at about the same weight as Mr. Nicholson's motor; this would have only half his rotor K.E. and of the other parts the brake drum at least and its K.E. could be reduced similarly. Results would be still more favourable in comparison with Mr. Nicholson's were the crane a D.C. one with torque, productive of acceleration, rising approximately as the square of the current.

I am aware that under either alternative the K.E. of the rotating parts is still left at a fairly high value relatively to that of the actual load, high enough in fact to be the controlling factor in acceleration. But even on Mr. Nicholson's crane the overload torque capacity must, 'if used,' be sufficient for acceleration to full speed in two seconds at most, and that Mr. Nicholson declines to use this overload capacity does not alter the fact that it is there for use and the motor has been built to give it.

As regards the hydraulic crane figures, the column of water that I had in mind as having to be accelerated was not that in the cylinder, but the whole column back to the nearest accumulator. The K.E. of this depends mainly on the size of the pipes and the consequent speed of flow and is distinct from pressure drop due to friction. The hydraulic efficiency figures look very high seeing

Correspondence—continued

that the crane starts from 80 per cent. efficiency $\left(\frac{\text{full load } 100\%}{125\% \text{ load}}\right)$ water pressure losses alone apart from any operative losses.

This argument started from my saying that the acceleration of the electric was superior to that of the hydraulic crane. I said this from general experience in oversight of the very low actual speed of lift and kinetic energy of the load, but having regard to the well known overload capacity of the electric motor as against the definitely limited hydraulic overload capacity; I agree, however, that this is more than sufficient to provide for the low kinetic energy of the load being imparted very rapidly. Though I do not agree with Mr. Nicholson—and I do not think his traffic operating officers would agree either—that the saving of a few seconds per cycle is negligible, it is a minor point.

If Mr. Nicholson would seriously contemplate putting down hydraulic cranes for a new installation, using his electricity through pumps, to operate them at a greatly enhanced cost for energy compared to straight electric, I venture to suggest he is the only Dock Engineer who would do so. As I have said before I cannot agree that hydraulic maintenance costs are "very much less" than electric and the latter cranes of modern good make are certainly not unreliable; cables definitely cost less for maintenance than pressure mains. As for drainage and heating, frosts have been known to be of months duration and have put complete hydraulic installations out of action altogether. On a busy installation the repacking of glands and the periodic re-turning and eventual replacement of rams cost a good deal in themselves.

Yours faithfully,

J. DALZIEL.

Camosan, Berks Hill,
Chorleywood, Rickmansworth.
June 10th, 1944.

To the Editor of "The Dock and Harbour Authority."

Tidal Levels of the Thames

Dear Sir,

I have read with great interest in your recent issues the article on "Tidal Levels of the Thames," by Mr. Wm. B. Hall, M.Inst.C.E. It is, I think, to be regretted that only an abstract of this valuable communication was published in the Journal of the Institution of Civil Engineers.

The historical review of the gradual establishment of a number of conflicting and erroneous datums, not to use the word *misleading* makes this aspect all the more important. Indeed, having all my life been concerned with maritime undertakings for various clients on the Thames-side below London Bridge, I find that the arbitrary fixing of Trinity High Water Mark at a fixed level for the whole length of river has always produced confusion of thought amongst my clients. That London should have a datum from which it measures downwards and all ports datums from which they measure upwards is an anachronism. Further, now the Newlyn Datum has come in we have its varying corrections along the line of the hitherto static figure of T.H.W, which makes it a movable datum as one passes down river from reach to reach.

In all survey work involving the taking of soundings in tidal waters in this country (one of which I am now engaged on) I have always been most careful to have the soundings directly and physically related to Ordnance Datum. The bed levels then get their depths of water automatically ascertained when it becomes possible to agree with the Port or Conservancy Authority concerned as to what the high and low water levels for Ordinary Spring Tides can be taken at for the area concerned.

In the no-man's land between maritime structures and land works, such as flood prevention embankments, working to a common fixed datum seems to me an essential factor.

For the general reasons given above and from long experience of the Thames, I am wholeheartedly in favour of a *fixed* datum now being laid down by the Port of London Authority, and after examining Mr. Hall's views in detail, I can suggest no better one than the London Zero Tide Level he puts forward, viz., "10 feet below Ordnance Datum, mean sea level at Newlyn," though I am not quite certain I like the term "zero" as a title. Something like "London Low Water Level" would appeal more, I think, to the Mercantile Marine.

With Mr. Hall I find it necessary to use the plural "datums" instead of data, so do not apologise for it.

Your Journal has done good service in publishing this paper in full.

Yours faithfully,

ERNEST LATHAM, M.Inst.C.E.

16, The Fairway,
Gravesend, Kent.
8th June, 1944.

To the Editor of "The Dock and Harbour Authority."

Collapse of New Zealand Wharf

Dear Sir,

On page 235 of the February, 1944, issue of *The Dock and Harbour Authority*, in the course of an article entitled "Notes on Dock Wall Design and Construction," a description is given of the collapse of a "pile structure," which is alleged to have occurred at Lyttelton Harbour, New Zealand.

An illustration on the same page includes in its caption the reference:—"See Minutes Inst.C.E., vol. 226, P. 183—Williams."

As the description of the disaster given in this reference commences with the sentence: "In December, 1924, he (Mr. Williams) was appointed a member of a commission formed to investigate the cause of the collapse of a reinforced concrete breastwork wharf in Auckland, New Zealand," I find it difficult to understand how the author of the article gained the impression that it occurred at Lyttelton.

I trust that you will give suitable prominence in a future issue to a correction of the error.

Yours faithfully,

PERCY W. FRYER, M.Inst.C.E.
Secretary and Engineer.

Lyttelton Harbour Board.
New Zealand.
24th April, 1944.

The above communication has been referred to Mr. R. D. Brown the author of the article, who is now on active military service. He desires to express his regret for the mistake and to tender his sincere apologies to Mr. Fryer and the Lyttelton Harbour Board.

Death of P.L.A. Official.

We regret to have to record the death of Mr. Ernest Edward Lee Vincent, M.Inst.C.E., which took place in May at the early age of 59. Mr. Vincent entered the service of the Port of London Authority as an Assistant Surveyor in 1911. A year later, he was transferred to the dock engineering staff and took part in various constructional works at Tilbury, Royal Albert and Victoria, and India Docks, including the major alterations to the Western Entrance of the Royal Docks, of which he was in charge. In 1930, he was appointed to a Research Committee of the Authority as engineering advisor. While serving in this Committee, he introduced mechanical appliances for the handling of wool imports at the London and St. Katharine Docks, for which he received special recognition from the Authority. In 1935, Mr. Vincent became Superintendent of this group of docks, and four years later was promoted to the Superintendence of the Royal Docks, the largest and most important London system. His duties were carried out during the intensive enemy air attacks on the port. In February, 1941, he was seconded to the Port and Transit Control of the Ministry of War Transport to assist in matters relating to dock engineering under war-time conditions. In addition to membership of the Institution of Civil Engineers, Mr. Vincent was also a Member of the Institution of Mechanical Engineers.

The Design of Piled Structures

By P. GARDE-HANSEN, B.Sc.,
Assistant Manager, Christiani & Nielsen, Ltd.

(Continued from page 40)

Remarks regarding placing of piles.

From the formulæ developed, some general conclusions can be drawn with regard to the most rational manner of placing the piles.

As it is generally desired to make the pile-group as rigid as possible, which is the same as making φ as small as possible, we see that it is desirable that the pile-group has a large I, because

$$\varphi=\frac{M}{I}$$

This can be obtained by spreading the piles as much as possible within each group of parallel piles of which the entire pile-group is composed.

From the general formula (10) we see that the pile-loads increase with H, V and M. H and V cannot be altered, as they depend upon the exterior forces only. M is, however, dependent upon the location of O, which again depends upon the arrangement of the piles. If we resolve H and V into their resultant, we find a line with regard to any point of which the moment of the exterior forces is =O. If O is situated on this line, we have M=O and the pile-loads are the least possible. It is, however, not always possible to arrange the piles so that this condition is fulfilled. The limitation of the area in which the piles can be placed and of the batter under which it is practical to drive piles, may render it impossible. Much can, however, be done in arranging the piles so that O comes as close to the line mentioned as possible.

With regard to the batter or rake under which piles can be driven, 1 : 3 or 1 : 4 are generally considered the limit, and general purpose frames are rarely designed for driving piles raking more than 1 : 3. With specially designed frames, where the hammer e.g., runs on rollers on the leader, the writer's firm has driven piles inclined 1 : 1½ and another firm has since driven piles inclined 1 : 1. A very considerable economy has in this way been obtained in providing foundations for two or three hinged frames forming the skeleton of hangars or similar structures.

From the more special formula for pile-loads in groups consisting of two sets of parallel piles we see that piles in the r-group must be in tension for positive H if $\angle < n_1 \times H$, and that piles in the l-group must be in tension for negative H, if $\angle < n_2 \times H$; the factor dependent on M will, namely, either be = O or have both positive and negative values. For a given n_1 we can find the n_2 that gives minimum pile-loads. Calling $n_1=n$ and $n_2=x$, we have :—

$$y=\frac{\sqrt{1+x^2}}{n+x}$$

$$\frac{dy}{dx}=\frac{n\times x-1}{(n+x)^2\times\sqrt{1+x^2}}=O,\text{ i.e., } x=\frac{1}{n.}$$

$$\frac{d^2y}{dx^2}=\frac{2+n+n^2+x-nx-n^2x-nx^2-2x^2-2nx^3}{(n+x)\times(1+x)^2\times 1+x^2}$$

or for

$$x=\frac{1}{n}\ \frac{d^2y}{dx^2}=\frac{(1+n^2)\times n}{(n^2+1)^3\times(n+1)^2\times\sqrt{n^2+1}}>O$$

which proves y=minmum for $x=\frac{1.}{n}$

As the piles cannot be driven under $\frac{n}{1}$ this shows that they should be driven to as great an inclination as possible.

Symmetrical pile-groups will generally be supporting piers that may alternately have the maximum load from the left and from the right. O must always be on the axis of symmetry; in order to decrease M, it should be close to the intersection between the axis of symmetry and the resultant of the exterior forces. To obtain this and a large I at the same time, the batter piles should be under the centre portion of the pier and the vertical piles as close to the circumference of same as possible. This is, however, very often impracticable, on account of the difficulty in driving the batter piles crossing the vertical piles, or *vice versa*, as the first set of piles driven will have compressed the ground, making the driving of the second set very difficult, if not impossible.

The application of formulæ developed above and of the general rules outlined will now be shown by some examples.

Examples 1 to 4 (Figs. 10, 11, 12 and 13) illustrate the application of the principle to the four special types of pile-groups for which special formulæ have been developed.

Example 5 (Figs. 14 and 15) shows the more general application of the principle. The structure to which it is applied is the so-called "quay wall with relieving platform." The introduction of reinforced concrete into harbour and dock construction enabled the development of this type of wharf, which was first designed and built by Messrs. Christiani and Nielsen in 1906. It has since then become one of the most, if not the most, generally used construction when the depth of water exceeds 18 to 20 feet, as it—in this case—is more economical than both the anchored wall of sheet piles and the old-fashioned mass concrete or masonry wall.

The application of the above developed principle of design to many "quay walls with relieving platform" built up to now will, however, show that the designer has not fully understood the problem involved in the arrangement of the piles and uneconomical and unbalanced structures have been the result. Example 5 gives an instance of this, as it shows the calculations of the pile-loads for two different arrangements of piles under the same conditions in regard to surcharge, depth of water, tidal variations, etc. In fact, the properly designed wharf was proposed—and adopted—as an alternative to the other, and carried out in one of the largest ports in the Antipodes.

A comparison of the two designs shows a saving in the number of piles of 30 per cent. and at the same time a reduction of the maximum pile-load from 70.3 tons to 55.2 tons and a more equal distribution of the total load over the piles. Furthermore, the quantities in the superstructure have been greatly reduced.

It is the writer's hope that this article will be of use to engineers responsible for the design of piled structures and that it will lead to more economical and rational designs than are now frequently seen.

EXAMPLE 1. (All piles parallel.)

Foundation for Brick-lined Steel Chimney.

The horizontal component of the wind pressure is assumed counteracted by the earth resistance on the side of the pile cap; further, that this is of such depth and width that the earth resistance is equal to or greater than 1½ times the wind pressure.

Loads	Without Brick Lining	With Brick Lining
V	270 tons	450 tons
M	1,000 ft. tons	1,000 ft. tons

$$I_x=6\times 8.00^2+4\times 4.00^2=448\quad \frac{I_x}{Z\ max.}=56$$

$$I_y=2\times 11.30^2+6\times 5.65^2=448\quad \frac{I_y}{Z\ max.}=40$$

The maximum pile-loads will be caused when the wind is square to Y—Y, and are :—

Without brick lining

$$\frac{270}{12} \pm \frac{1000}{40} = \begin{cases} 47.5 \text{ tons} \\ -\ 2.5 \text{ tons} \end{cases}$$

With brick lining

$$\frac{450}{12} \pm \frac{1000}{40} = \begin{cases} 62.5 \text{ tons} \\ 12.5 \text{ tons} \end{cases}$$

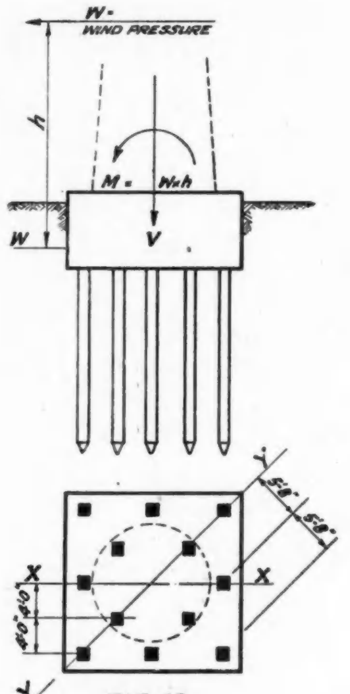


FIG. 10.
(EXAMPLE 1.)

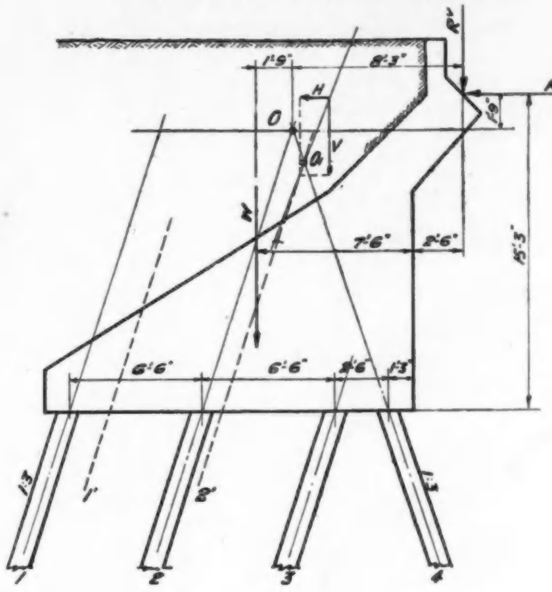


FIG. 11.
(EXAMPLE 2.)

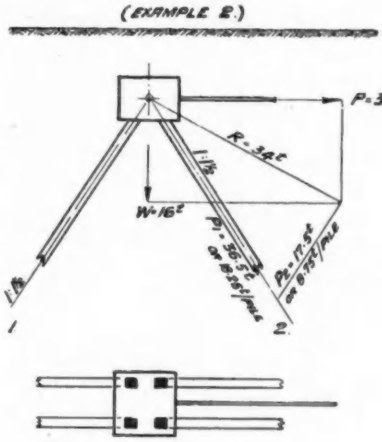


FIG. 13.
(EXAMPLE 4.)

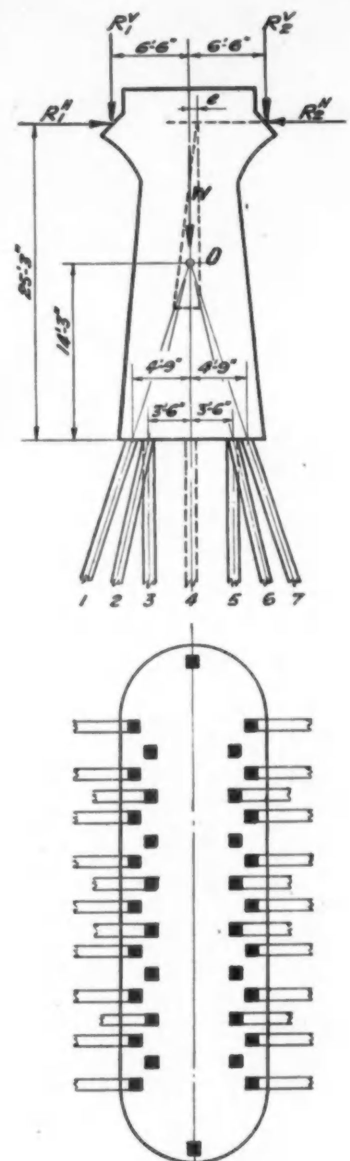


FIG. 12.
(EXAMPLE 3.)

EXAMPLE 2. (Piles in two groups of parallel piles.)
Foundation for a two- or three-hinged arch.

Vertical component of reaction from arch $= R^V = 270$ tons.
Horizontal component of reaction from arch $= R^H = 300$ tons.
Weight of abutment and fill over same $= W = 485$ tons.

The reaction and the weights are acting in the lines indicated on the figure. The O-point is determined as explained previously.

$$V = W + R^V = 755\ t$$
$$H = R^H = 300\ t$$
$$M = 270 \times 8.25 - 300 \times 1.75 - 485 \times 1.75 = 850 \text{ ft. tons.}$$

$$\frac{\sqrt{1+n_1^2}}{n_1+n_2} = \frac{\sqrt{1+n_2^2}}{n_1+n_2} = \frac{\sqrt{10}}{6} = 0.527$$

$$\frac{n_1 \times \sqrt{1+n_1^2}}{n_1+n_2} = 3 \times 0.527 = 1.581$$

$$\frac{1}{mr} = \frac{v}{\Sigma\, v} = \frac{1}{1} = 1\ ;\ \frac{1}{m_l} = \frac{v}{\Sigma_l v} = \frac{1}{3} = 0.333$$

$$\frac{V}{I} = \frac{1}{\Sigma z^2} = \frac{1}{2 \times 6.5^2} = \frac{1}{84.5}\ ;\ \frac{\sqrt{1+n_1^2}}{n_1} = \frac{\sqrt{10}}{3} = 1.054$$

$$\frac{V}{I} \times \frac{\sqrt{1+n_1^2}}{n_1} = 0.0125$$

$$\text{r group} = \frac{\sqrt{1+n_2^2}}{n_1+n_2} \times \frac{v}{\Sigma_r v.} = 0.527. \qquad n_2 \times 0.527 = 1.581$$

$$\text{l group}: \frac{\sqrt{1+n_1^2}}{n_1+n_2} \times \frac{v}{\Sigma_l v} = 0.176. \qquad n_1 \times 0.176 = 0.527$$

The pile-loads are then :—

$$P1 = 0.176 \times 755 + 0.527 \times 300 + 0.0125 \times 850 \times 6.5 = 360 \text{ tons}$$
$$P2 = 0.176 \times 755 + 0.527 \times 300 = 291 \text{ tons}$$
$$P3 = 0.176 \times 755 + 0.527 \times 300 - 0.0125 \times 850 \times 6.5 = 360 \text{ tons}$$
$$P4 = 0.527 \times 755 - 1.581 \times 300 = -76 \text{ tons}$$

Assuming a permissible pile-load of 45 tons compression respectively 10 tons pull the following numbers of piles are required :—

$$\frac{360}{45} = 8 \text{ in each of rows 1–3} \qquad \frac{76}{10} = 8 \text{ in row 4}$$

i.e., the total number of piles $= 32$.

Referring to the concluding remarks on the placing of the piles, a more economical pile arrangement is obtainable by fixing the O-point as the intersection O1 between the resultant of H and V and the centre of gravity line for pile group 4, and hence from O1 draw a line under the inclination of 1 : 3 and fix this line as the centre of gravity line for pile groups 1 to 3. Pile group 2 will then be on line 2′ and pile group 1 on line 1′ when pile group 3 is retained in its original position, and the approximate pile loads are :—

$$P1 + P2 + P3 = 3 \times (0.176 \times 755 + 0.527 \times 300) = 873 \text{ tons}$$
$$P4 = (0.527 \times 755 - 1.581 \times 300) = -76 \text{ tons}$$

Design of Piled Structures—*continued*

or $ml=\frac{873}{45}=22$ and $mr=\frac{76}{10}=8$

and $\frac{ml}{mr}=2.75$ i.e. $\frac{\sqrt{1+n_1^2}}{n_1+n_2}\times\frac{1}{mi}=\frac{0.527}{2.75}=0.192$

and $n_1\times\frac{\sqrt{1+n_1^2}}{n_1+n_2}\times\frac{1}{m_1}=3\times0.192=0.576$

i.e. $P1+P2+P3=3\times(0.192\times755+0.576\times300)=954$ tons

and $m=\frac{954}{45}=22$ piles distributed as follows :—

Row 1 : 7 piles. Row 2 : 8 piles. Row 3 : 7 piles. And the total number of piles=30.

The example illustrates that a small alteration to the pile arrangement in accordance with the rules outlined results in a saving, in this case of 2 piles out of 32.

EXAMPLE 3. (Pile group consisting of piles arranged symmetrically with regard to a vertical plane square to the plane of the resultant.)

Intermediate foundations for a series of two- or three-hinged arches.

A pier of this description is to be designed for the span on one side having maximum surcharge and the span on the other side having no surcharge. The thus designed pier should be thereafter examined for :—

1. Maximum surcharge on both spans.
2. The various loads that may occur during construction.
3. The case when one span has been demolished and there is no surcharge on the other span.

The loads in the present case are from Deadweight Rv=200 tons
RH=220 tons

Deadweight of arches only : Rv =32 tons
RH=36 tons

Surcharge (live load) : Rv =70 tons
RH=80 tons

Weight of pier W=475 tons

1. Surcharge on one side of pier only.

$V=2\times200+70+475=945$ tons

$H=$ 80 tons

$V\times e=945\times e=70\times6.5$ $e=0.48$

The pile-loads are in accordance with formula $\overline{(13)}$:—

a. Raking piles

$$P=\frac{1}{\cos\alpha}\times\left[V\times\frac{v}{\Sigma v}+H\times\frac{v\tan\alpha}{\Sigma v\tan^2\alpha}\right]$$

b. Vertical piles

$$P=V\times\frac{v}{\Sigma v}+M\times\frac{v\times z}{I}$$

Assuming all piles being of the same material and having the same section and compression length, i.e. $\frac{E\times A}{S}$=constant, then is :

$$\frac{v}{\Sigma v}=\frac{\cos^2\alpha}{\Sigma\cos^2\alpha}\times\frac{v\tan\alpha}{\Sigma v\tan^2\alpha}=\frac{\cos\alpha\times\sin\alpha}{\sin^2\alpha}$$

$$\frac{V}{I}=\frac{\cos^2\alpha}{\Sigma Z^2\times\cos^2\alpha}$$

$\tan\alpha_1=\tan\alpha_7=\frac{4.75}{14.25}=0.333$ $\tan\alpha_2=\tan\alpha_6=\frac{3.50}{14.25}=0.250$

$\cos\alpha_1=\cos\alpha_7=0.952$ $\sin\alpha_1=\sin\alpha_7=0.317$ $\cos\alpha_2=\cos\alpha_6=0.972$
$\sin\alpha_2=\sin\alpha_6=0.243$ $\tan\alpha_3=\tan\alpha_4=\tan\alpha_5=0$
$\sin\alpha_3=\sin\alpha_4=\sin\alpha_5=0$ $\cos\alpha_3=\cos\alpha_4=\cos\alpha_5=1$
$M=70\times6.5-80\times11.0=-325$ ft. ton.

$1.054\times945\times0.030=30.3$		30.3
$1.054\times\ 80\times0.153=12.9$		−12.9
	P1=43.2	P7=17.4
$945\times0.033=$	P4=31.8	
$325\times0.036=$	11.6	
	P3=43.4	
$1.032\times945\times0.031=30.6$		30.6
$1.032\times\ 80\times0.123=10.2$		−10.2
	P2=40.8	P6=20.4
945×0.033	=31.8	
325×0.036	=11.6	
	P5=20.2	

By the help of the coefficients calculated in Table III., it is easy to calculate the pile-loads for any other set of loadings, e.g. the pile-loads at the time when the span to the right is entirely completed, but in the span to the left the arch only is completed.

In this case we find :

Piles	1	2	3	4	5
Load	52.0	46.1	56.1	23.3	−9.5
Piles	6	7			
Load	−0.7	−7.4			

These loads exceed those in the finished structure with a maximum of 25 per cent. which, however, is quite permissible, as they occur temporarily only.

Pile	No of Piles	$\frac{1}{\cos\alpha}$	$\cos^2\alpha$	$\sin^2\alpha$	$\cos\alpha\times\sin\alpha$	$n\times Z^2\times\cos^2\alpha$	$n\times\cos^2\alpha$	$n\times\sin^2\alpha$	$\frac{V}{\Sigma V}$	$\frac{V\tan\alpha}{\Sigma V\tan^2\alpha}$	$\frac{V\times Z}{I}$	Pile Load
P1	n= 8	1·054	0·910	0·101	+0.302	0	7·28	0·808	0·030	0·153	0	43·2
P2	3	1·032	0·945	0·059	+0·242	0	2·83	0·177	0·031	0·123	0	40·8
P3	4	1·000	1·000	0	0	49	4·00	0	0·033	0	−0·036	43·4
P4	2	1·000	1·000	0	0	0	2·00	0	0·033	0	0	31·8
P5	4	1·000	1·000	0	0	49	4·00	0	0·033	0	0	20·2
P6	3	1·032	0·945	0·059	− 0·242	0	2·83	0·177	0·031	−0·123	+0·036	20·4
P7	8	1·054	0·910	0101	− 0·302	0	7·28	0·808	0·030	−0·153	0	17·4
Sum	32		6·710	0·320	0	98	30·22	1·970				

TABLE III.

EXAMPLE 4. (Piles intersecting each other on a line square to the plane of the resulting forces.)

Anchorage for a sheet piled quay wall.

It is necessary that the resultant of the pull in the rod and the weight of the pile cap shall pass through the intersection line for the piles. It has further been proved that it is most advantageous to have the piles as raking as possible. In the present example it has been found simpler to determine the pile-loads graphically ; but the theory developed has been used in arranging the piles.

EXAMPLE 5.

Quay wall with relieving platform.

Loadings	Original Proposal	Alternative
Dead load	631 per sq. ft.	975 per foot
Surcharge	672 per sq. ft.	672 per foot
Total ..	1,303 per sq. ft.	1,647 per foot

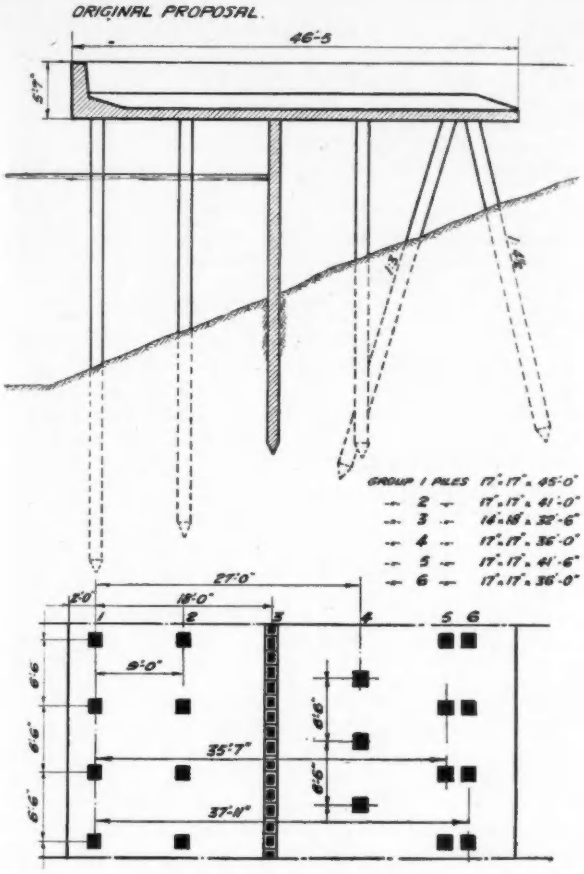


FIG.14. (EXAMPLE 5.)

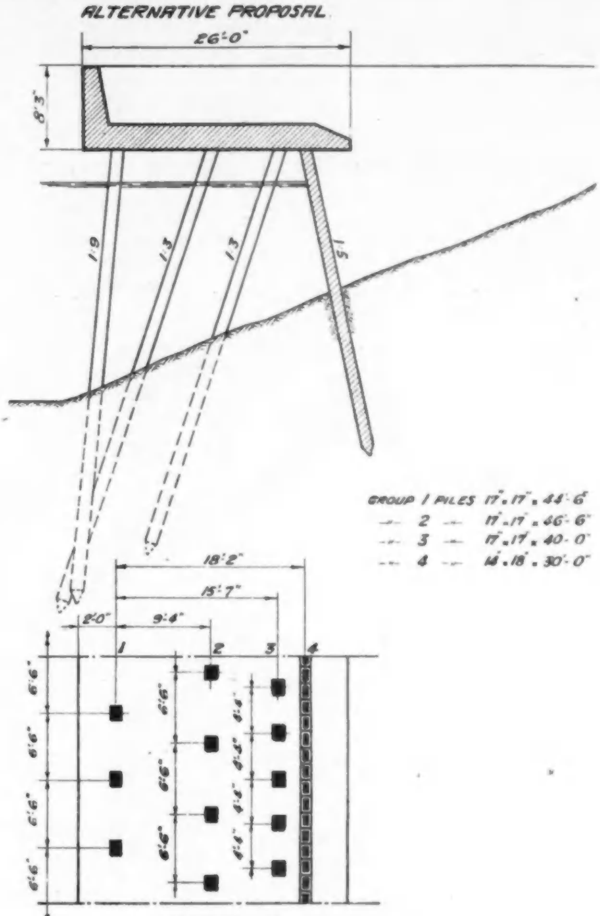


FIG.15. (EXAMPLE 5.)

TABLE IV.

PILE	$\frac{A}{51}$	X	$\cos\alpha$	$\tan\alpha$	V	$V\tan\alpha$	VX	$VX\tan\alpha$	$V\tan^2\alpha$	Z	VZ	VZ^2	C_1	C_2	C_3
ORIGINAL PROPOSAL															
1	1·04	0	1·000	0	1·04	0	0·	0	0	−20·20	−21·20	429	0·093	−0·032	−0·0165
2	1·15	9·00	1·000	0	1·15	0	10·35	0	0	−11·20	−12·90	145	0·103	−0·035	−0·0102
3	5·40	18·00	1·000	0	5·40	0	97·20	0	0	−2·20	−11·95	26	0·485	−0·163	−0·0093
4	1·31	27·00	1·000	0	1·31	0	35·37	0	0	+6·80	+8·80	60	0·118	−0·040	0·0069
5	1·11	35·60	0·950	0·333	1·00	0·333	35·58	11·86	0·111	+14·91	+14·90	222	0·084	+2·050	0·0122
6	1·30	37·95	0·976	−0·222	1·24	−0·276	47·06	−10·45	0·061	+18·06	+22·35	404	0·124	−1·680	0·0180
TOTAL Σ =					11·14	0·057	225·56	1·41	0·172			1286			
ALTERNATIVE PROPOSAL															
1	1·16	0·	0·994	0·091	1·15	0·105	0	0	0·009	−13·28	−15·4	204	0·121	0·242	−0·0584
2	1·11	9·30	0·950	0·333	1·00	0·333	9·3	3·10	0·111	−0·87	−0·9	1	0·121	0·685	−0·0032
3	1·88	15·60	0·950	0·333	1·70	0·567	26·5	8·83	0·189	+5·43	+9·1	49	0·205	1·110	0·0358
4	6·48	18·20	0·981	−0·200	6·24	−1·248	113·1	−22·68	0·249	+1·20	+7·2	9	0·582	−2·035	0·0276
TOTAL Σ =					10·09	−0·243	148·9	−10·69	0·558		0	263			

	ORIGINAL PROPOSAL.	ALTERNATIVE PROPOSAL.
$\tan\alpha_1$ =	0.005	− 0.024
$\tan\alpha_2$ =	2.980	− 2.290
x_1 =	20.25	14.75
x_2 =	24.75	44.00
y_0 =	− 1.51	12.80
x_0 =	20.20	14.44

ORIGINAL PROPOSAL:

$$M = -1{,}51\,H_1 - 7.08\,H_2 + 1.00\,V$$

ALTERNATIVE PROPOSAL:

$$M = 12.80\,H_1 + 4.55\,H_2 - 3.44\,V$$

or per 6 feet 6 inches length of wharf :—

Dead load	83 tons	74 tons
Surcharge	89 tons	50 tons
Total ..	172 tons	124 tons

Reaction from earth pressure on superstructure and sheet wall acting at top of piles
$H_1 = 20.4$ tons 40.7 tons

Pull at top of wharf from ships moored alongside
$H_2 = 6.5$ tons 6.5 tons

Loading 1. Dead load only above relieving platform. Surcharge behind relieving platform.
Loading 2. Surcharge also above relieving platform.
Loading 3. As loading 1 plus pull at top of wharf.
Loading 4. As loading 2 plus pull at top of wharf.

Formulae applied :—

$$v = \frac{E \times A}{s_1} \times \cos^2 \alpha \text{ or as } E = \text{constant}$$

$$v = \frac{A \times \cos^2 \alpha}{S_1}$$

$$\tan \alpha_1 = \frac{\Sigma v \tan \alpha}{\Sigma v} \qquad \tan \alpha_2 = \frac{\Sigma v \times \tan^2 \alpha}{\Sigma v \times \tan \alpha} \qquad X_1 = \frac{\Sigma v \times X}{\Sigma v}$$

$$X_2 = \frac{\Sigma v \times X \times \tan \alpha}{\Sigma v \times \tan \alpha} \qquad C = X_1 - X_2 \qquad Y_0 = \frac{c}{\tan \alpha_2 - \tan \alpha_1}$$

$$X_0 = X_1 + \frac{c \tan \alpha_1}{\tan \alpha_2 - \tan \alpha_1} \qquad Z = X_0 - X - Y_0 \times \tan \alpha \qquad I = v \times Z^2$$

$$P = \frac{1}{\cos \alpha} \times \left[V \times \frac{v}{\Sigma v} \times \frac{\tan \alpha_2 - \tan \alpha}{\tan \alpha_2 - \tan_1} + H \times \frac{v}{\Sigma v \times \tan^2 \alpha} \times \frac{\tan \alpha - \tan \alpha_1}{\tan \alpha_2 - \tan \alpha_1} + M \times \frac{v \times z}{I} \right] = \left[C_1 \times V + C_2 \times H + C_3 \times M \right] \times \frac{\text{pile pitch}}{6.5}$$

For notations see Fig. 8.
From the sketches is derived : for 6 ft. 6 in. length of wharf :

Pile group	Area in sq. feet					
	1	2	3	4	5	6
Original proposal ..	2.00	2.00	7.60	2.00	2.00	2.00
Alternative proposal	2.00	2.00	3.00	7.60	—	—

The relative values only of $\frac{A}{S_1}$ have been indicated in table IV., and the pile loads are calculated in table V.

ERRATA.

Page 20, line 42. Formula $S = \frac{I}{F \times R,}$ should read $S = \frac{R}{F}$

Page 19, second half of Doerr's formula should read $\frac{1}{2} \times W \times L^2 \times u \times (1 + \tan^2 \theta)$

Page 39, line 54. A vertical moment should read A vertical movement

CALCULATION OF PILE LOADS.

$$P = \left[C_1 \times V + C_2 \times H + C_3 \times M \right] \times \frac{\text{pile pitch}}{6.5}$$

LOADINGS.		I	II	III	IV
ORIGINAL PROPOSAL.					
V =	ton.	83·0	172·0	83·0	172·0
H =	ton.	20·4	20·4	26·9	26·9
M =	ft. ton.	43	93	3	47
ALTERNATIVE PROPOSAL.					
V =	ton.	74.0	124.0	74·0	124·0
H =	ton.	40·7	40·7	47·2	47·2
M =	ft. ton.	269	95	299	125

LOADINGS.		I	II	III	IV
ORIGINAL PROPOSAL.					
PILES IN GROUP	1	6·3 t.	14·8 t	6·7 t	14·3 t
	2	7·5 t.	16·0 t	7·7 t	16·3 t
	3	8·5 t.	18·1 t	8·7 t	18·2 t
	4	9·3 t.	20·1 t	8·7 t	19·5 t
	5	49·3 t.	57·4 t	62·2 t	70·3 t
	-6	pull 33·1 t.	pull 11·3 t.	pull 34·8 t	pull 23·1 t
ALTERNATIVE PROPOSAL.					
PILES IN GROUP	1	2·6 t.	18·9 t	2·5 t	18·8 t
	2	34·7 t.	41·4 t	39·0 t	45·7 t
	3	46·7 t.	49·4 t	52·5 t	55·2 t
	4	pull 6·8 t.	pull 1·1 t	pull 9·6 t.	pull 3·9 t.

TABLE V.

Death of Chairman of Dockyard Company.

The death has been announced of Mr. David Wylie Gairns, chairman of the Grangemouth Dockyard Co., Ltd., one of the best known men in the industry in the East of Scotland area.

Seaplane Base Project on the Tyne.

It is understood that negotiations are in progress between the Tyne Improvement Commission and the Corporations of South Shields and Jarrow in connection with a project for establishing a seaplane base at Jarrow Slake.

Association of Consulting Engineers.

At the recent Annual General Meeting, Mr. David M. Watson, B.Sc., M.Inst.C.E., was elected chairman of the Association for the year 1944-45. This is the second time in the history of the Association that the son of a former chairman has succeeded to the Chair. The roll of membership is now the highest hitherto attained.

New Wharf at Vancouver.

A new wharf, with a warehouse, estimated to cost two and a half million dollars, is to be constructed for the Royal Canadian Navy at the harbour of Vancouver, British Columbia. The new wharf and warehouse will be adapted to commercial use after the war, and will be handed over to the Canadian National Harbour Board.

Death of Chairman of Harbour Commissioners.

The death, at the age of 74, is announced of Mr. Joseph Storer Clouston, of Smoogro House, Orkney, who has been Convenor of Orkney since 1930 and chairman of the Orkney Harbour Commissioners since 1935. He was a novelist, historian and playwright.

Resignation of Tyne Commissioners.

The resignations from membership of the Tyne Improvement Commission of Sir Arthur Lambert and Alderman Edwin Gibbin have been announced. Sir Arthur Lambert had served on the Commission for 12 years, and Alderman Gibbin for just under 25 years. A tribute to both gentlemen was paid by the Chairman, Sir Arthur Sutherland, at the last meeting of the Commission.

The Institution of Civil Engineers.

Following the successful establishment of several Engineering Divisions on such subjects as Roads, Railways and Structural Engineering, the Council of the Institution of Civil Engineers announce in their Annual Report for 1943-4 that, having been pressed to establish a new Division dealing with harbours and docks, together with works of coastal protection and the like, they have decided to establish a Maritime Engineering Division " with the general object of the advancement of the science and art of engineering in relation to the development of harbours and ports, the construction of docks and quays, coast and estuary protection, and the reclamation of land from the sea." The arrangements for the next session are in the hands of a provisional Board, comprising the following: Messrs. Asa Binns (chairman), Guthrie Brown, F.M.G. Du-Plat-Taylor, R. D. Gwyther, Sir William T. Halcrow, Shirley Hawkins, M. G. J. McHaffie and W. P. Shepherd-Barron.

The Institute of Transport.

The Council of the Institute of Transport has elected **Mr. Robert Kelso** to be President of the Institute for the year 1944-45. Mr. Kelso, the Chairman and Managing Director of the General Steam Navigation Co., Ltd., became a Member of the Council of the Institute in 1935 and continued to serve on the Council until 1938, during which period he was for two years Vice-Chairman of the Membership and Examinations Committee. From 1938-41, he was a Vice-President of the Institute and served as Chairman of the Membership and Examinations Committee and as a Member of the General Purposes and Finance Committees, 1938-39, and as as Member of the war-time Executive Committee, 1939-41. Since his retirement from the office of Vice-President, Mr. Kelso has been a Member of the Examinations Committee, upon which he is still serving.

Notable Port Personalities

XLIII—Col. Sir Frank R. Simpson, Bt.

Col. Sir Frank R. Simpson, Bt., C.B., T.D., J.P., D.L., deputy Chairman of the Tyne Improvement Commission, was born on the 12th April, 1864, son of the late Dr. J. B. Simpson, D.C.L., J.P., whom he succeeded on the Board of the Tyne Improvement Commission as a representative of the Coalowners.

Col. Sir FRANK SIMPSON, Bart.

Sir Frank was educated at Rugby School, after which he embarked on a career as a Mining Engineer. At the outbreak of the European War, 1914-18, he was in command of the 9th Battn. D.L.I., and later the 2-9th Battn D.L.I., with the British Salonika Force, 1914-18 (despatches twice, two medals). He has had a long association with the Territorial Army, serving as Lt.-Colonel Commanding and later Hon-Colonel, 9th Battn. D.L.I (T.A.), and as Chairman of the Territorial Army and Air Force Association for the County of Durham. He was High Sheriff for the County Palatine in 1935. He has been a Member of the Board of the Tyne Improvement Commission for 23 years, representating coalowners' interests (he is Managing Director of Stella Coal Co., Ltd.), and during those years has been Chairman of the River Works Committee and since 1935, Deputy Chairman of the Board.

Sir Frank is a Member of the North of England Institute of Mining and Mechanical Engineers, of which he was President in 1921 and again in 1935. In 1939 he was President of the Institution of Mining Engineers. He is a Member of the Institution of Civil Engineers. He served on the Durham County Council for 27 years. He is a Knight of Grace of St. John of Jerusalem, and has been a Member of Ryton Urban District Council since 1897.

Institute of Transport.

Mr. A. H. J. Bown, general manager and secretary of the River Wear Commission has been elected chairman of the Northern Section of the Institute of Transport.

Post-War Organisation of British Transport

Report by the National Executive Committee of the Labour Party

The recently issued Report by the Labour Party on the post-war organisation of British Transport is mainly concerned with traffic by rail and road. In the latter portion of the Report there are sections on Canals and Inland Waterways and on Harbours and Docks which are reproduced below. The Report advocates the formation of a National Transport Authority to control and administer all forms of transport with separate boards for each.

Canals and Inland Waterways.

In each section of transport, states the report, we have considered the Government has had to apply control in one form or another, but in no section has the need been more essential than in the case of canals, where the pre-war standard of development left much to be desired.

The United Kingdom has, having regard to its size, a fairly extensive system of canals and inland waterways, but in almost all cases, the canals, which date from the pre-railway era, have not by modern transport standards, a high efficiency. There are, in the United Kingdom just over 2,100 miles of canal-way, of which 1,300 miles accommodate barges of 14-ft. and over in breadth, carrying between 60 and 150 tons. The remaining 800 miles of waterway take boats of 7-ft. and over in breadth, which carry only between 20 and 30 tons. The breadth of the canal, or the locks in the canal, is an important limiting factor. Another is the shortage of water, e.g., the Oxford Canal has not been worked since the latter part of 1943, and the Grand Union Canal has not been worked since the latter part of 1943, and the Grand Union Canal has had to pump water back at great cost, in order to fill its locks at the height of one of its rises. If, therefore, the canals were to remain as they are, it would be desirable to increase the supply of water from some source. The canals, however, ought not to remain as they are. They should be enlarged and modernised, wherever practicable or desirable.

At their peak, British canals carried 40,000,000 tons annually; but by 1938 the figure had dropped to 13,000,000; and had it not been for the war it is reasonable to expect that the total might have dropped still further. During the war it may be assumed that traffic has fluctuated between 11,000,000 and 13,000,000 tons annually.

For the pre-war years the biggest class of cargo was coal, coke and similar fuel, which amounted to almost half the annual tonnage, and the next largest, bulk liquids, such as tar and oil, which averaged out at approximately 12 per cent. of the total carried.

Railway competition was responsible for the first drop in the volume of traffic carried by the canals, and subsequently road competition also affected the amount carried. There are, however, other industrial factors which one must expect permanently to affect canal transport, e.g., iron-ore deposits have been exhausted and consequently heavy industries situated on canal banks have disappeared, or have opened up elsewhere; waterside collieries and quarries have been worked out; many mills have moved—some to the sea ports; factories which previously relied upon raw coal for power have now gone over to electricity; a factor which has contributed substantially to changes in the location of industry; the use of different materials in the construction and maintenance of roads has also had an effect on waterways traffic.

The four main groups of canals from their geographical disposition are known as the "Cross." They connect the Thames, Severn, Humber and Mersey with the Midlands, centering on Birmingham. There are also minor connections between the Humber and the Mersey, and between the Thames and the Humber. There is also a canal connecting the rivers Clyde and Forth.

The railway companies own about 600 miles of canal. The canal companies, excepting three, do not act themselves as carriers, but provide and maintain the canals, and their revenue is mainly derived from tolls.

Capital expenditure on the canals totals approximately £30,000,000, of which the railway companies carry about £8,000,000. The capital of the carrying or trading firms is probably about £7,000,000. As is to be expected from the shrinkage of traffic the earning power of the canal companies is very low. In 1938, the Railway Companies on their canal operations showed a net loss of £65,000. Independent canal companies, in the three years before the war, showed a return from all sources of less than 2 per cent. on capital. On this return more than half is accounted for by rents for canal lands, water and investments. Probably as little as a third of it was earned directly from trade through the canals.

The pre-war administration of canals was diverse—railway companies, independent companies, commissions, catchment and drainage boards. To meet war-time demands, the Minister of War Transport has imposed a degree of co-ordination. There are six regional canal committees, the chairman of each sitting on the Central Canal Committee under the Parliamentary Secretary to the Minister of War Transport. He exerts control by virtue of a Defence Regulation. At the beginning of the war, canal companies were permitted to raise their tolls, and the Treasury met half of the toll charges by the canal carriers. Where canal companies had to build premises, or acquire equipment, to handle Government traffic, these capital charges were met by the Government. In certain cases, where it could be shown that a company could not afford maintenance costs on canals which the Ministry of Transport thought essential, special grants were made after enquiry.

The canal system has elements of great value to the nation, and it should be developed as an integral part of the national transport system. This will have to be a long-term policy if results in national efficiency are to be secured commensurate with expenditure involved. Waterways should be made capable of handling large barges, and the locks of dealing with traffic at fair speed.

A Canal and Waterways Board.

A Canal and Waterways Board should be established. The Board would be charged with development and operation, and be responsible to the National Transport Authority. Day to day operation would be delegated to the regional bodies, each of which would be represented on the Canal and Waterways Board.

The National Authority in consultation with the board should determine:—(a) what canals are capable of long-term development; (b) what other canals it is strategically desirable should be maintained against war-time uses; (c) what other waterways, not falling into these two categories, must be maintained open because of drainage or water supply necessities. These should be transferred to the authority charged with the care of the country's water supply

In arriving at its decision, the Board would be influenced by an enquiry into the type of goods which are most suitable for conveyance by waterways, and where cargoes of this type can be found for two-way traffic upon the canals. No systematic enquiry of this kind seems to have been undertaken, and it might with profit be undertaken at an early date.

It has been argued that the canal carriers should not be acquired at the same time as the acquisition of the waterways. But as the building of suitable craft seems to have been neglected equally with the canals, both no doubt due to the same causes, we contend that the canal authority should have power to build and operate as carriers, and to rent, acquire, or compensate existing carriers. This would permit the authority to allow existing carriers to function until such time as the authority itself decided to take over completely the function of carrying.

Harbours and Docks

Allied to canals, and of course a connecting link between them, the railways and coastal shipping, which must also fall within the scope of any survey of domestic transport, are harbours and docks.

Broadly speaking, dock facilities and methods in this country have a high efficiency. During the war the Government, through

Post-War Organisation of British Transport

(continued)

the Ministry of War Transport, has had to exert control. Regional Port Directors were appointed; stevedores and their equipment rented; dock labour de-casualised and shipping directed by the Ministry to available ports as circumstances required.

Harbour and dock managements fall into five categories:

(1) Local statutory bodies, usually carrying municipal representatives.
(2) Municipal Authorities.
(3) Railway Companies.
(4) Harbour Companies.
(5) Admiralty and Ministry of War Transport.

These authorities, between them, own and manage something like 340 separate undertakings. The deficiencies in our port services were thus mainly due to lock of co-ordination, not only nationally, but in each estuary excepting the Thames. In the case of the Thames a single conservancy has now been successfully operating for more than 30 years.

The National Transport Authority should acquire all harbours and docks. In addition, a Board of Harbours and Docks should be established with powers similar to those for other sections of transport. The Board, acting for the Authority, should undertake a survey to determine, with reasonable margins for expansion, what is the probable port capacity for the Kingdom; decide how this capacity should be distributed, and bring the most suitable ports in the country to the highest standard of modernisation.

The National Dock Labour Corporation

Annual Meeting

The Annual Meeting of the National Dock Labour Corporation, Ltd., was held in London on June 27th. It was presided over by Lord Ammon, the recently appointed chairman of the Corporation.

The Annual Report states that there were 38,969 port transport workers in Corporation ports at December, 1943. At the meeting the number was stated to be 42,435 on June 13th.

Chairman's Address

In his address, **Lord Ammon** said that the outstanding characteristic which obtrudes from any survey of the industry was the continuing surplus of labour on any given day. That was a problem which was continually exercising the minds of the directors. There would always be some surplus labour on any given day; a dock could not be worked with the continuity of a factory, but they must distinguish between the surplus normal to the work of the industry and the abnormal surplus. In peace days many men, temporarily unemployed in industries near to the docks, flocked to the stands to swell the numbers of those not engaged; registration of the docker did not prevent that influx entirely. There were also many men included in the surplus to-day who, having given a lifetime of service to the industry, could only take occasional work of a limited kind. They would hate to be barred from the docks, but until some alternative method of securing their livelihood was found they would attend the calls and only secure odd light jobs occasionally.

The Corporation and the industry would need to examine the problem of surplus labour more closely. It has always been a characteristic of the industry. Indeed, it was too often taken for granted that there must be a floating population of unemployed "on the stones." Those days were past. But any plans for the continued decasualisation of the docker after the war could not succeed unless the volume of surplus labour to be carried was related to the needs of the industry. Casual labour was expensive and wasteful in the dock as in any other industry.

Any such inquiry would proceed to distinguish between the normal surplus required to man the industry, taking into account seasonal variations, as distinct from the abnormal surplus of war or peace, to ensure that available work was evenly spread among the dockers. Further, if the labour force was to give efficient outturn it must consist of able-bodied workers. Absence and inefficient work, arising trom accident or unfitness, must be tackled at source by limiting as far as was possible the causes and providing adequate medical and rehabilitation services.

There was still much progress to be made in the field of welfare. The directors were at the moment examining the problems involved in improving the health provision for dockers. Although the problems to be met in the docks were more widespread, of longer standing, and consequently more intractable than those in many other industries, they intended to devise schemes which would reduce the toll taken by ill-health and accidents. Already they had initiated discussion with hospital and other authorities concerned to bring into operation comprehensive schemes for port medical services and rehabilitation treatment.

All their plans were ultimately tested on the quayside, where corporation officers and men met at the calls. Whereas previously those meeting places were often in the open or, if covered at all, in unsuitable premises, they had now erected 28 new control points and ten others were in course of building. They provided covered accommodation for 14,000 men. That was no mean achievement in wartime, and the new buldings were recognised by the men as a sign of a new order in the industry.

The immediate needs of the war situation would continue to dictate much of their immediate policy, but it was going to be increasingly important that they should take counsel with the industry as to the future of the scheme. The Reinstatement of Civil Employment Act, 1944, Sect. 7, referred to "employers of any class" who were restricted to using workers "for the time being in a specified pool," and the body controlling the pool was, for the purposes of the Act, the employer. The industry would thus have certain post-war obligations to ex-Service dockers. In addition, there were many peacetime dockers now in other industries who would look to the docks for employment after the war. The industry must plan their return.

In the course of the meeting, Mr. Bevin, Minister of Labour, paid a well-deserved tribute to those who had assisted in the invasion operations. "The loyalty and magnificent work," he said, "of dockers, stevedores, port managements and all concerned, has contributed largely to the success of Invasion Day."

The United States Waterways Experiment Station at Vicksburg

(Concluded from page 53)

means of maintaining the project channel. Although these findings are negative, they are far from valueless since without the model results one of the plans might have been tried in the prototype at considerable expense.

A somewhat similar study is that currently under way of the Head of Passes reach of the Mississippi River situated about 100 miles below New Orleans (see photograph). At this point the river divides and flows into the Gulf of Mexico through several outlets of which only South and Southwest Passes are navigable. The entrance channel at the head of South-west Pass requires annual dredging, and it is hoped to develop a plan during the model study which will improve and maintain this pass from its head to the Gulf. Tides are not reproduced in this model since the tidal fluctuations are so slight as to be negligible.

From the foregoing descriptions of the typical problems studies at the Experiment Station it may be seen that the small-scale model has not only played an important part in the development of waterways during normal times, but that it has also been drafted into service for defence purposes. It is expected that with the programme of public works being considered for post-war years, the model study will take an even more prominent place in hydraulic problems.